Psychological Bulletin

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EMPIRICAL EVALUATIONS OF HUMAN FIGURE DRAWINGS[1]

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Since the publication, in 1949, of Karen Machover's *Personality Projection in the Drawing of the Human Figure* (55) the Draw-A-Person Test (DAP) has become an instrument used routinely by many clinical psychologists. In the eight years that have elapsed since the publication of Machover's monograph many research studies on the DAP have been published. It seems desirable at the present time to examine the hypotheses Machover presented in her monograph in the light of the empirical evidence that has accumulated.

It is the purpose of this paper to attempt to analyze all of the research on the DAP reported in the literature from January, 1949, to December, 1956. Machover's hypotheses will be examined in the light of the evidence produced by these studies.

RELIABILITY

Machover (55, p. 6) states that "structural and formal aspects of drawing, such as size, line, and placement, are less subject to variability than content, such as body details, clothing, and accessories." Machover goes on to state that *S*s render

consistently such features as the following: size of the figure, placement of the figure on the page, kinds of lines (long, continuous lines versus short, jagged ones), stance of the figure, proportions of the body, observance of symmetry compulsions, tendency to incompletions, presence of erasures, and presence of shading.

Both Bradshaw (13) and Lehner and Gunderson (49) have attempted to determine the reliability of both the structural aspects of figure drawings and the content of figure drawings. Since the aspects of figure drawing that they investigated overlap considerably, these two studies will be considered together.

Bradshaw (13) gave the DAP as a group test to 100 psychology students, both male and female, ranging in age from 19 to 55, with a mean age of 27.57. He used the test-retest method with one week between the two administrations of the test. Bradshaw considered 25 different body areas or parts in his study. He scored for 17 possible different kinds of drawing treatment, and each body area or part was scored for as many of these kinds of drawing treatment as were applicable to it. For example, the hands were scored for whether they were present or not, whether they were clothed or not, presence of erasing, presence of shading, degree of detailing, proportional size, line

quality, and shape. Bradshaw determined reliability primarily by percentage of consistency from the first administration of the test to the second administration of the test. If, for example, of 10 drawings, four had shading on the hands of both drawings and five had no shading on the hands of either drawing, and one had shading on one drawing and no shading in the other drawing, there would be 90 per cent consistency for shading in the treatment of the hands. However, he did use in addition the product-moment correlation coefficient in determining the consistency of quantifiable dimensions such as distance from the side of the paper, distance from the top of the paper, and vertical height. These were measured in centimeters.

Lehner and Gunderson (49) gave the DAP to 91 psychology students, ranging in age from 18 to 26, with four months between the two administrations of the test. They also determined reliability by the test-retest method and in addition investigated intrajudge reliabilities and interjudge reliabilities. They scored the drawings on 21 "dimensions," using rating scales for the scoring. The authors report that most of the rating scales had 10 points, but some of the rating scales had as few as 2 points. They do not present the scales used to rate the dimensions. The authors state that "all results are per cent of agreement between the sets of ratings, i.e., per cent of cases in which the matched ratings are identical."

Table 1 summarizes the reliabilities reported by Bradshaw and Lehner and Gunderson on the content as indicated earlier. Bradshaw scored each body part on several different scales. For example, the hands might be scored for presence vs. absence,

TABLE 1

RELIABILITIES OF DAP CONTENT REPORTED BY TWO STUDIES

DAP Part	Bradshaw		Lehner & Gunderson
	Range[a,b] Per cent	Mean Per cent	
Whole drawing	(100–66)	84	—
Whole head	(100–59)	78	—
Whole trunk	(100–59)	83	—
Legs and feet as whole	(100–62)	75	—
Arms	(99–44)	72	—
Mouth	(94–50)	68	44
Lips	(74–54)	65	—
Chin	(91–57)	74	—
Eyes	(96–55)	76	61
Eyebrows	(90–68)	78	—
Ears	(78–62)	70	—
Hair	(84–35)	68	70
Nose	(97–55)	74	52
Face	(79–73)	76	—
Neck	(95–55)	68	—
Arms	(99–65)	77	—
Hands	(97–55)	76	67
Fingers	(87–54)	70	—
Legs	(98–60)	74	—
Feet	(97–54)	75	56
Shoulders	(96–59)	73	—
Hips, buttocks	(83–45)	65	—
Waistline	(78–60)	66	—
Breasts	(100–50)	71	42
Crotch	(78–44)	68	—

[a] All figures represent percentage of agreement.
[b] All parts were rated for many different characteristics, such as line quality, proportion, shape, etc.

presence of erasures, presence of shading, etc., so that for each body part several different percentages of agreement were reported. The range of these percentages of agreement is presented in the table, and to the immediate right of the range the mean of the ratings for that particular part is presented. It will be noted that Bradshaw found the lowest percentage of agreement (65%) on the lips and the hips and buttocks. He found the highest percentage of agreement (84%) in rating the whole drawing. Lehner and Gunderson found the lowest percentage of agreement

(42%) on the breasts and the highest percentage of agreement (70%) on the hair.

Table 2 summarizes the reliabilities reported by the two studies on the structural and formal aspects of the DAP, based upon the analysis of the same drawings as reported in Table 1. Bradshaw reports three reliabilities (distance from top of paper, distance from left side of paper, and vertical height) in product-moment *r*s. All other figures are percentage of agreement. In this table also, Bradshaw had several ratings for each of the aspects of the drawings. For example, presence of shading was rated in regard to several different body parts such as the arms, hands, face,

etc. In this table the range of percentage of agreement obtained by Bradshaw is reported, and to the immediate right of it the mean of the percentages of agreement is presented.

Bradshaw reports the lowest percentage of agreement (60%) on the shape of the figure and the highest percentage of agreement (90%) on the presence or absence of the various parts of the body. The three *r*s Bradshaw reports are all significant at the .01 level of confidence.

Lehner and Gunderson report the lowest percentage of agreement (45%) on the position of the figure on the page, and the highest percentage of agreement (93%) on body type.

TABLE 2

RELIABILITIES OF STRUCTURAL AND FORMAL ASPECTS OF DAP
AS REPORTED BY TWO STUDIES

DAP Aspect	Bradshaw		Lehner & Gunderson
	Range[a,b] Per cent	Mean Per cent	
Presence of parts	(100–72)	.90	—
Presence of clothing	(98–65)	86	—
Presence of erasing	(98–54)	69	56
Presence of shading	(93–62)	76	59
Presence of accessories	—	75	—
Profile vs. full-face	(72–85)	80	65
Direction of profile	(70–89)	83	—
Sex first figure	—	68	—
Distance from left of paper	—	$r = .46$[d]	45[e]
Distance from top of paper	—	$r = .54$[d]	45[e]
Vertical height	—	$r = .61$[d]	—
Degree of detailing	(65–90)	76	79
Proportional size	(52–100)	64	—
Line quality	(50–84)	72	71
Shape	(35–75)	60	—
Stance	(44–96)	72	78
Reinforcement	—	—	64
Body type	—	—	93
Transparency	—	—	77
Position of hands	—	—	46
Extraneous drawing	—	—	75
Symmetry	—	—	60

[a] All figures percentage of agreement unless otherwise noted.
[b] Several aspects were rated for presence on several different parts of DAP.
[c] Reported as "position on page," such as head, legs, breasts, etc.
[d] Significant at the .01 level.

It will be recalled that Machover suggested that the structural and formal aspects of the DAP tend to be more reliable than the content. In order to give a comparison of the percentages of agreement obtained by Bradshaw and Lehner and Gunderson, Table 3 was prepared. In Table 3 the number of parts falling at each level of percentage of agreement for the body parts and the structural and formal aspects of the DAP for each study is presented. It will be noted that there is no great difference between the percentages of agreement on the content and the percentages of agreement on the structural aspects of the DAP.

Serious criticism must be leveled against the use of the percentage of agreement as a measure of reliability. The significance of the percentage of agreement on the DAP is entirely dependent upon the base rate of the particular body part or structural aspect of the drawing that is being investigated. The "base rate" refers to the frequency with which a particular sign is ordinarily present in the population of Ss that is being studied. Meehl and Rosen (60) have pointed out the importance of including the base rate in the validation of a clinical instrument. The more frequently a particular sign is found in a particular part of the DAP, the higher the percentage of agreement must be in order to be significant. If a particular sign is drawn by 90% of the population on the DAP, then a consistency of 82% would not be significant. This is illustrated in Table 4. Table 4 is a purely fictional table designed to illustrate this point. It will be noted in Table 4, on the first administration of the DAP, that of 1,000 subjects 900, or 90%, drew hands and 100, or 10%, omitted the hands. On the second administration of the DAP to this same group 90% drew hands and 10% omitted the hands. So, it may be stated that the base rate for the drawing of hands on the DAP for this particular sample is 90%. Of those who drew hands on the DAP at the first administration 810, or 81% of the total sample, also drew hands on the DAP at the second administration. Of those who omitted the hands on the first administration 10 or 1% of the total sample also omitted the

TABLE 3

PERCENTAGE AGREEMENT OF DAP CONTENT COMPARED WITH PERCENTAGE AGREEMENT OF STRUCTURAL AND FORMAL ASPECTS OF DAP

| Percentage of Agreement Level | No. of Items Reaching Percentage of Agreement Levels | | | |
| | Bradshaw | | Lehner and Gunderson | |
	Content	Structural Aspects	Content	Structural Aspects
90–100	0	1	0	1
80–89	2	3	0	0
70–79	16	5	0	5
60–69	7	4	3	3
50–59	0	0	2	2
40–49	0	0	2	3

TABLE 4

HYPOTHETICAL FREQUENCIES DEMONSTRATING HOW PERCENTAGE OF AGREEMENT CAN BE HIGH AND RELIABILITY LOW

| DAP Second Administration | DAP First Administration | | Totals |
	Hands Present	Hands Omitted	
Hands present	810	90	900
Hands absent	90	10	100
Totals	900	100	1,000

$\chi^2 = .00$
ϕ/ϕ maximum $= .00$
% agreement $= 82\%$

hands on the second administration of the DAP. Adding the 81% who drew hands on both administrations to the 1% who omitted the hands on both administrstions, we arrive at a figure of 82% consistency on the presence or absence of hands. However, if we calculate the significance of this relationship by either chi square or ϕ/ϕ maximum[2] we find that in both cases we obtain a result of .00. In other words, we have obtained 82% consistency, but it is not a statistically significant relationship, and the correct conclusion should be that the presence or absence of hands on the DAP has zero reliability.

Since neither Bradshaw nor Lehner and Gunderson report the base rates of the various parts and aspects of the DAP, it is impossible to tell the actual significance of the percentages of agreement that they report. Therefore, with the exception of the product-moment rs reported by Bradshaw, the author would suggest that these studies do not provide valid estimates of the reliability of the DAP.

Wagner and Schubert (79) developed a scale for rating the "quality" of the DAP. They constructed this scale by having-judges grade the drawings of 75 college girls into 7 categories ranging from the poorest to best quality. The closer a drawing came to resembling a "real life-like person" the higher it was to be rated in the quality categories. With this scale they obtained interjudge reliabilities of approximately .90 for experienced judges and .85 for inexperienced judges. The reliability of the quality of the same-sex figure for 176 coeds in a school of education was .86, apparently using the test-retest method and employing experienced

[2] This point was suggested by Dr. E. E. Cureton.

judges for assessing reliability. The authors did not report the amount of time between the two administrations of the DAP.

Wagner and Schubert's study suggests that the "quality" of the DAP, when judged as a whole, is reliable. Bradshaw's data (13) suggest that the placement of the figures on the page and the size of the figures also appear to be reliable, but less reliable than judgments of the quality of the total figure. No other data are available to determine the reliability of the other parts or aspects of the DAP, or to evaluate the validity of Machover's hypothesis that the structural and formal aspects of the DAP are more reliable than the content of the DAP.

RESEARCH APPLYING TO THE "BODY-IMAGE" HYPOTHESIS

The basic hypothesis underlying figure drawing interpretation is that when a person responds to the request to draw a picture of a person he draws a picture of himself. This is sometimes called the "body-image" hypothesis. Machover (55, p. 35) states that "the human figure drawn by an individual who is directed to 'draw a person' relates intimately to the impulses, anxieties, conflicts, and compensations characteristic of that individual. In some sense, the figure drawn *is* the person, and the paper corresponds to the environment. This may be a crude formulation, but serves well as a working hypothesis."

Unfortunately, there have been few studies that would appear to bear at all upon the question of whether or not human figure drawings do, in fact, represent the drawer's perception of himself.

Berman and Laffal (10) come the closest to testing the hypothesis. They were interested in determining

if *S*s, when instructed to draw a picture of a person, tend to draw a figure that represents themselves, or draw an idealized figure, or draw a figure that shows no discernible relationship to themselves. They used as their basic data the human figures drawn by 39 male patients in a VA hospital. Using an inspection technique, they rated the body type of the patient. They used Sheldon's types as the categories into which they placed the *S*s. They then rated the body type of the figures drawn by these patients, and correlated the ratings of the patient with the ratings of the drawings. The authors do not describe how they converted their ratings into numerical scores from which a Pearson "*r*" could be computed. They obtained a Pearson *r* of .35, which is significant at the .05 level of confidence. These results suggested to the authors that when an *S* is asked to draw a figure he tends to draw the type he is most familiar with, i.e. his own. However, inspection of Berman and Laffal's data shows that only 18 of their 39 *S*s drew figures that were judged to be of the same body type as the *S*'s body. This suggests the possibility that for some *S*s the figure drawn represents the *S*'s own body, but that for the majority of *S*s the figure drawn represents something else.

In connection with a series of studies of obese women, Kotkov and Goodman (47) made a careful investigation of the differences between the human figures drawn by obese women and the figures drawn by ideal-weight women. They used as *S*s 25 obese and 20 ideal-weight women who were matched as groups for age, educational level, IQ, marital status, and the "career vs. housewife" dichotomy. They compared both the male and female figures drawn by the *S*s on 43 items of measurement. They ran 129 chi-square tests of significance and found that 32 of them were significant at the .20 level or better. Of the 32 chi squares that were significant at the .20 level, seven were found to be significant at the .05 level of confidence. In view of the fact that 129 chi squares were computed, this suggests the possibility that the significant statistics were due to chance alone. But examination of the report shows that most of the significant differences were due to the greater area on the page covered by the obese female. Kotkov and Goodman suggest that the female figures drawn by their subjects did represent a projection of the body image.

But the authors feel that certain inconsistencies in their results "lead us to look for the operation of dynamic personality principles in the determination of differences between the groups." In other words, they feel the body-image hypothesis accounts for only part of the differences they obtained.

Lehner and Silver (48) and Giedt and Lehner (30) were interested in determining the ages assigned to the figures drawn by *S*s. These studies do not provide data showing a relationship between the physical dimensions of the patient's body and the dimensions of the figure he draws, but they do suggest a relationship between a characteristic of the *S* and the characteristics he assigns to the figures he draws. In the first study (48) the DAP was given to 229 men (ages 17 to 45) and 192 women (ages 18 to 54). It was found that as the *S*'s chronological age increased he tended to ascribe a higher age to the figure he had drawn. This tendency continued until age 25 when the age of the figure drawn ceased to increase as rapidly as the *S*'s age. This change in rate seems

to be more pronounced for female Ss than for men subjects. Both sexes tended to assign older ages to the male drawing than to the female drawing. The authors also noted that the men tended to draw male and female figures that were similar to each other, and that this same tendency was noted in the women Ss. The second study (30) used as Ss 188 male neuropsychiatric patients in a VA hospital and 229 male students in a psychology class. The authors found that the age assigned to the figure drawn tends to increase with an increase in the S's age, but that younger Ss (students under 25 and patients under 35) tend to assign ages to the figures that are older than the subject's own age, and the older Ss (students over 30 years old and patients over 40 years old) tend to assign ages to the figures that are younger than the S's age.

Prater (66) compared the human figure drawings of hemiplegic patients with the drawings of a matched group of normals. He was interested in determining whether or not there was any relationship between hemiplegia and the drawing of heads and limbs. He used as an experimental group of Ss 49 hemiplegics and a control group of 43 normals. He obtained the ratio of the area covered by the head to the area covered by the trunk of the figure drawing, and also measured the length of the limbs of the drawings of both groups. He found no significant differences between the drawings of the normals and the hemiplegics on relative head size. He found that the drawings of the hemiplegics showed no tendency to emphasize the head or the limbs by excessive shading or by any other means. He found no differences between the limbs either on the part of the limbs that were on the same side

of the body as the hemiplegics' paralyzed limbs, or those that were on the same side of the body as the hemiplegics' normal limbs. These results suggest that, for hemiplegics at least, abnormalities of the body are not reflected in the drawings.

These few studies suggest that there is slight basis for believing that the figure drawn usually represents the S's own body. The results suggest that for many, or perhaps most, Ss the figure drawn does not represent the S's own body. Goldworth (32), on the basis of a review of the literature that had been published prior to 1948, has suggested that the body-image hypothesis may only be valid for Ss whose perceptions are determined primarily by senses other than the visual. He also points out that for adult Ss the drawings reflect the S's ability to evaluate his own drawing, and thus reflect his capacity for self-criticism. He feels that research into factors affecting an S's ability for self-criticism would also throw some light on the meaning of human figure drawings.

It is apparent from the few studies reviewed above that the most outstanding conclusion that can be drawn is that definitive research on the basic meaning or significance of human figure drawings is lacking.

CONTENT AND STRUCTURAL AND FORMAL ASPECTS OF DRAWINGS

Machover (55, p. 21) stresses that, in interpreting the DAP, the patterns of the traits in the drawings must be considered when they are being interpreted. But she suggests that particular kinds of treatments of particular parts of the body tend to have a particular significance. Therefore, in the section that follows, the hypotheses of Machover which apply to particular parts of the drawings, or

which deal with the meaning of a particular kind of treatment of a particular body part (e. g., shading the breasts) will be discussed.

In the following discussion the various parts of the body will be discussed, first presenting Machover's hypothesis concerning the meaning of various kinds of rendering of the part of the body under consideration, followed by the results of the applicable studies. Discussion of those parts of the body for which no research is reported in the literature has been omitted.

In the following discussion any statistic that is referred to as being "significant" is significant at the .05 level or higher. The specific level of significance will not be mentioned unless it is below the .05 level, or unless the level of significance is of particular interest. This is done to eliminate much awkward repetition.

Head

Machover (55, p. 36) feels that "the head is essentially the center for intellectual power, social balance, and the control of body impulses." A disproportionately large or small head suggests that the S is having difficulty in one of these areas of psychic functioning. For the most part, none of the studies get at any of the above factors directly. Perhaps the investigator to come the closest was Cook (21) who found that, in a group of 21 male college students, those who drew the female head larger than the male head attributed the "social function" to the female to a significantly greater degree than to the male. Cook determined "social function" by a 15-item attitude scale.

Goodman and Kotkov (35) found no significant relationship between the size of the head on the DAP and repression or inhibition.

Machover (55, p. 37) also suggests that disproportionate heads will often be drawn by individuals who are suffering from organic brain damage, preoccupied with headaches, or other special head sensitivity, and that this will be because of the weakened intellectual power and control which fixates consciousness on the head as the primary organ in the hierarchy of body values. She, in addition, hypothesizes that "a youngster whose emotional or social adjustments have been dislocated because of a severe reading or other subject disability will frequently draw a large head on his figure," and that "the mentally defective will . . . often give a large head." She also feels that the paranoid, narcissistic, intellectually righteous, and vain individual may draw a large head as an expression of his inflated ego, and that the inadequate male will draw the female figure with a much larger head than the male figure. Several studies bear directly on these points. Fisher and Fisher (28) obtained DAP's from 32 paranoid schizophrenics. They rated these drawings on six signs Machover considers indicative of paranoid schizophrenia (eye emphasis, large grandiose figure, speared fingers, large head, rigid stance, and large ears). They found that only 13 of the 32 drawings had as many as 3 of the signs present. They concluded that their results cast doubt upon the validity of these signs, including the large head, as being indicative of paranoid schizophrenia. Holzberg and Wexler (44) compared 38 schizophrenic female patients with 78 student nurses on 174 scoring items of the DAP, including head size. Eighteen paranoid schizophrenics were included in their group of patients. They found no significant differences between the normals and paranoids in head size.

Prater (66) compared the DAP's of 49 male hemiplegics with a matched group of 43 normal males. He found no significant difference between the two groups in head size. Royal (67) found no significant difference between the shape of the head on DAP's rendered by 80 VA Mental Hygiene Clinic patients diagnosed as anxiety neurosis and the DAP's rendered by 100 VA dental patients. De Martino (25) found no significant difference between the head size of the DAP's of mentally retarded homosexuals and mentally retarded normals.

On the other hand, Goldworth (32) found significant differences between the heads drawn by normals, neurotics, psychotics, and brain-damaged patients. He compared the drawings of 50 normals, 50 neurotics, 50 psychotics, and 50 brain-damaged patients on 51 scoring items of the DAP. He scored each of the items with a rating scale. He tested the significance of the differences between the diagnostic groups of Ss with the chi-square technique. In addition to testing for the significance of the differences between the diagnostic groups, he also tested for the significance of the differences between the male and female Ss, using the chi square. He found differences significant at the .05 level or higher on 38 of the 51 scoring items. He found that normal Ss tend to draw heads that are more accurate, better proportioned, and better differentiated than heads drawn by neurotic, psychotic, or brain-damaged subjects. He particularly noted that the brain-damaged subjects tended to draw heads that were either grossly disproportionate or omitted significant details. Rarely, according to Goldworth, does a brain-damaged S draw a head that is reasonably correctly porportioned, with the correct shape,

and containing the essential details that are included in a normal head. His research suggests that the normal tends to draw a "normal head"; neurotics tend to draw heads that are generally fairly accurate, well proportioned, well differentiated, and containing the essential details of a human head, but not quite as good as heads drawn by normals; that schizophrenics tend to draw relatively more frequently distorted heads, inaccurate heads, misproportioned heads, or heads with significant details missing; and brain-damaged generally draw the least well-proportioned heads. His research also suggests that there is a considerable amount of overlap between these groups. Kotkov and Goodman (47) found that obese females tended to draw heads that were significantly larger than females of normal weight. However, since obese females draw figures that cover a larger area of the page than normal females do, it might be considered that the larger head area is a function of the general tendency of the obese female to draw a larger figure.

The Face

According to Machover "the face is the most expressive part of the body" (55, p. 40). Machover feels that the face is the center of communication and that it is the easiest part of the body to draw. She states that Ss who draw the head as the last feature usually show disturbance in interpersonal relationships. Subjects who deliberately omit facial features in their drawings are evasive about the frictional character of their interpersonal relationships. She feels that omitting facial features is a graphic expression of the avoidance of social problems. She states that superficiality, caution, and hostility

may characterize the social contacts of an individual who omits drawing the facial features. However, she does feel that occasionally normal Ss will omit them.

Holzberg and Wexler (44) found no significant differences between normal Ss and schizophrenic Ss in the presence or absence of facial features. On the other hand, Margolis (58), in reporting the case of a schizophrenic girl treated by outpatient psychotherapy, noted that at the end of nine months of therapy this girl drew facial features last in sequence on the DAP. Margolis suggests that this indicates the difficulty the girl had in facing the world. However, this girl is reported as having improved her interpersonal relationships while in therapy.

Facial expression. According to Machover (55, p. 42), facial expression is one of the characteristics of drawings which may be judged directly with considerable confidence. Machover feels that regardless of the S's skill he unconsciously sets the tone for the drawing by giving the figures expressions of fear, hate, aggression, meekness, etc. She mentions, for example, that schizoid individuals will frequently draw a facial expression reflecting autistic and narcissistic preoccupation, with "large size and aborted or blocked movement trends to reinforce the fantasy quality of the subject's ego concentration."

Fisher and Fisher (28) found that there was low agreement among seven judges judging facial expression on drawings taken from 32 paranoid schizophrenics. The authors mentioned the fact that they repeatedly ran across wide disagreement between one rater and another in the judgment concerning the facial expression. In this study Fisher and

Fisher used two psychiatrists, three psychologists, and two stenographers as judges. Only the psychologists had experience in figure-drawing analysis. However, the highest agreement among judges on the facial expression was between the two stenographers who agreed in regard to 13 of the 32 DAP's. On the other hand, Goldworth (32) found significant differences between normals, neurotics, psychotics, and brain-damaged patients on facial expression. He noted that neurotics' drawings show fewer instances of "happy" expressions and more of "unhappy" expressions than the normal Ss. Schizophrenics show by far the largest incidence of "peculiar" and "doll-like" facial expression. The brain-damaged group resembles the schizophrenic group in the sense that they do not often draw "happy" expressions. The brain-damaged group shows many instances of an "unhappy" expression. "Empty" expression on a figure is drawn almost exclusively by brain-damaged subjects.

The mouth. According to Machover (55, p. 43), "Oral emphasis is marked in the drawings of young children, primitive, regressed, alcoholic, and depressed individuals. Since the mouth is often the source of sensual and erotic satisfaction, it features conspicuously in the drawings of individuals with sexual difficulties. Overemphasis of the mouth is frequently tied up with food faddism and gastric symptoms, profane language, and temper tantrums." According to Machover, mouth detailing with the teeth showing is considered an index of infantile, oral aggression often seen in simple schizophrenics or hysterical types. The concave or orally receptive mouth is, according to Machover, generally seen in the drawings of infantile, de-

pendent individuals. The mouth that is defined by a heavy line slash is generally an indication of aggression and is found in verbally aggressive, overcritical, and sometimes sadistic subjects. The mouth that is "heavy but brief," that is, one in which an individual starts to draw a heavy line slash but then suddenly withdraws from the page during the drawing, is generally found in individuals who are aggressive but who anticipate rebuff for their aggression and so withdraw cautiously. A single line for a mouth is generally considered by Machover to be an indication that the individual is shutting the mouth against something. This kind of mouth is sometimes seen in individuals who have had active homosexual experience. The wide, grinning mouth, giving the effect of a grinning clown, is interpreted as forced congeniality, an effort to win approval, or even inappropriate affect, depending upon other aspects of the drawing. Machover also states that asthmatics sometimes omit the mouth.

Holzberg and Wexler (**44**) found that normal women more frequently drew female figures in which the corners of the mouth were turned up and in which the mouth was shaded than schizophrenic women did. They found there were no significant differences between schizophrenic and normal women in the frequency of having the corners of the mouth turned down and having the mouth represented by a single line. They found that normal women more frequently had the mouth turned up than hebephrenic women, but that there was no significant difference between normal women and hebephrenic women in having the corners of the mouth turned down, having an object in the mouth, having the mouth open, or having the mouth represented by a single line. They found that normal women significantly more frequently had shading in the mouth than paranoid women, but there was no significant difference between normal and paranoid schizophrenic women in having the mouth open, having an object in the mouth, having the corners of the mouth turned down, or the corners of the mouth turned up, or in having the mouth represented by a single line. There were no significant differences between normal women and any classification of schizophrenic women in the presence or absence of teeth.

Cramer-Azima (**22**) found that a man recovering from the effects of exposure to beryllium dust showed changes in his treatment of the mouth that .were. concomitant with the changes in his behavior. He was originally meek, depressed, and uncooperative. At this time nothing unusual was noted about his mouth by the author. As treatment progressed he became moderately anxious, restless, and angry about certain conditions existing in his home. At this time he showed "aggressive treatment" of the mouth. After three weeks of treatment he was expansive, somewhat grandiose and anxious. At this time the teeth were featured in the mouth as well as other "aggressive" indicators. After discontinuation of treatment when he was feeling physically better and showing no overt signs of anxiety or hostility, it was noted that the drawing of his mouth showed fewer "aggressive" features.

Margolis (**58**), in noting the changes of the DAP of a 16-year-old schizoid girl during nine months of psychotherapy, noted that at the beginning of treatment the girl was fearful, childish, with no social activities, no

friends, and seeking to enter a convent. At this time she drew a mouth which was a "forced, grinning one." After nine months of treatment when the patient was more outgoing and sociable, and more efficient in intellectual functioning, she drew a mouth that was fuller but narrower. However, the author notes that at the termination of therapy the mouth was drawn with a more dissatisfied expression than in the drawings produced earlier in therapy.

Gutman (40), in comparing patients who improved in therapy to patients who did not improve in therapy, found no significant differences between the two groups in representing the mouth with a single line or in drawing the mouth open.

The lips. Lips are difficult to separate from the mouth in treatment as is indicated in some of the discussion which preceded in the case of the mouth. However, Machover states (55, p. 45) that full lips in a male figure generally indicate effeminacy and appear with other features reflecting "foppish and narcissistic interests." She states that individuals who draw lips that resemble a phallus have had homosexual experience. Girls drawing elaborate cupid-bow lips in combination with other heavily cosmetized features are generally sexually precocious. Objects drawn in the mouth, such as a straw or toothpick or, on a more sophisticated level, cigarette or pipe, generally indicate oral erotic trends.

Holzberg and Wexler (44) found that normal women significantly more frequently show line emphasis in the outline of the lips than schizophrenic women do. They found no significant difference between normals and schizophrenic women in shading the lips or drawing an object in the mouth. They found no signifi-

cant differences between normal women and hebephrenic schizophrenic women in drawing objects in the mouth, shading, or line emphasis in the lips. De Martino (25) found no significant differences between homosexual and nonhomosexual mentally retarded males in their drawing of the lips, or in placing an object in the mouth.

The eyes. According to Machover (55, p. 47), the eye can be regarded as the "window of the soul," revealing the inner life of the individual, " . . . (and) is a basic organ for contact with the outside world." Therefore, she feels that the eye is the chief point of concentration for the feeling of "self" and the vulnerability of "self." Since the eye is the window through which the self is revealed and also the means by which the individual maintains contact with the outside world, it follows that the individual who is most concerned with keeping contact with the outside world, namely the suspicious individual looking for hostility from the outside world, is most apt to emphasize the eye. The paranoid, of course, is the psychopathological category most nearly fitting this description, and therefore we would expect to find that the paranoid most frequently draws overemphasized eyes. People concerned with social functions are more apt to detail the eye, elaborating such things as eyelashes. Since females are more sociable than males, according to Machover, women would be expected to have a greater tendency to elaborate the drawing of the eyes. Also effeminate men, such as homosexuals, would be expected to elaborate the eyes and perhaps draw eyelashes on the figure. Machover mentions that homosexuals will sometimes draw eyelashes, and in addition draw a figure with a "well-specified

pupil." On the other hand, she states that people with a tendency to shut out the world will tend to draw figures with the eyes closed, or perhaps draw a circle for an eye and omit the pupil. She states that this is most apt to be seen in a patient who is emotionally immature and egocentric.

De Martino (25) noted that his homosexual mentally retarded males drew eyelashes on their figures significantly more often than the nonhomosexuals.

Gutman (40) found that patients who did not improve in therapy had a tendency to draw either piercing eyes or blank eyes. The piercing eyes would be characteristic of a paranoid schizophrenic, and the blank eyes characteristic of the simple schizophrenic or schizoid individual, both types having a poor prognosis for psychotherapy.

On the other hand, De Martino (25) found no significant differences between homosexual mentally retarded males and nonhomosexual males in the way they drew the parts of the eyes other than the eyelashes. Fisher and Fisher (28) were unable to differentiate between normal Ss and paranoid schizophrenic Ss using six DAP signs. One of the six DAP signs they used was eye emphasis.

Holzberg and Wexler (44) found that there was no significant difference between normals and paranoid schizophrenic women in any aspect of the eyes. However, they did find that hebephrenic women had a significantly greater tendency to draw eyes represented by circles, dots, or dashes and curves than normal women. Taking the schizophrenic group as a whole, however, they found that there was no significant difference between normal women and schizophrenic women in dealing with the eyes.

The eyebrow. Machover (55, p. 49) suggests that the eyebrow is probably related to other hair indicators. The trim eyebrow reflects the refined and well-groomed individual, while the bushy brow suggests the primitive, rough, and uninhibited individual. The raised eyebrow suggests disdain, haughtiness, or query.

Holzberg and Wexler (44) found that normals tend to be significantly more careful in detailing the eyebrows than schizophrenics, and normals tend significantly more often to have carefully detailed eyebrows than their paranoid schizophrenic subgroup. They found no significant difference between normals and schizophrenics in the presence or absence of eyebrows. De Martino (25) found no significant difference between homosexual and nonhomosexual mentally retarded males in the presence of eyebrows.

The ear. The ears, according to Machover (55, p. 50), are probably of less significance than some of the other parts of the body. However, if the ears are emphasized in a drawing, this suggests that the ears have been particularly sensitized for the individual who is doing the drawing. Particularly the paranoid individual, with his guardedness and suspiciousness, will likely give emphasis to the ears.

Holzberg and Wexler (44) found that schizophrenics draw either no ears, or ears where none should be, significantly more often than normals. However, when Holzberg and Wexler compared the normals with the paranoid and hebephrenic schizophrenics divided into subgroups, neither subgroup alone differed significantly from the normals in the drawing of the ears.

Gutman (40) found that the presence or absence of ears did not dif-

ferentiate significantly between patients who improved and patients who did not improve in psychotherapy. Fisher and Fisher (**28**) used large ears as one of the six signs by which paranoids might be distinguished from normals. In their study these signs did not differentiate the two groups.

The hair. Machover notes (**55**, p. 51) that hair emphasis, regardless of where it occurs, is generally considered an indication of striving for virility. This emphasis may be manifested by drawing a large amount of hair, with an elaborate coiffure, or with shading the hair. Machover feels that messy hair suggests immorality. A drawing of a hairy woman suggests the woman is viewed as being sexually passionate. She suggests that emphasis on wavy, glamorous, and cascading hair, when combined with other outstanding cosmetic details, is usually seen in the drawings of adolescent girls who are either sexually delinquent or entertain aspirations of an amorous sort.

Holzberg and Wexler (**44**) found that normals drew the hair inadequately significantly more frequently than their total group of schizophrenics. However, when the paranoid schizophrenic subgroup and the hebephrenic subgroup were independently compared with the control group of normals, no significant differences were found in the treatment of the hair. When Cramer-Azima's (**22**) beryllium-dust-poisoned man had received ACTH treatment for 21 days he began acting euphoric and exhibited considerable interest in a female patient. At this time he drew a female figure with glamorous and wavy hair.

Royal (**67**) was unable to find any significant difference between normals and anxiety neurotics in the shading of the hair. Gutman (**40**) was unable to find any significant difference between patients who improved and patients who did not improve in psychotherapy on the amount of hair drawn on the figure or on excessive detailing of the hair. De Martino (**25**) found no significant differences between homosexual and nonhomosexual mentally retarded males in hair treatment.

The nose. The nose is considered by Machover (**55**, p. 54) to be a sexual symbol. She suggests that patients having sexual difficulties or feeling sexual immaturity, inferiority, impotence, or other sexual insufficiency are inclined to emphasize the nose by either reinforcing it, making it larger, erasing, or shading, or other emphasized treatment of this sort. She suggests that impotence in the older male, for example, is often symbolically indicated in the drawing by an excessively long nose. On the other hand, it is suggested that the shaded or cut off nose is primarily related to castration fears, particularly castration fears stemming from autoerotic indulgence. She suggests that if nostrils are indicated with any degree of emphasis they are regarded as a specific accent on aggression.

Holzberg and Wexler (**44**) found no significant differences between normals and schizophrenics of any type in any aspect of the nose including size, shading, and shape. De Martino (**25**) found no significant difference between homosexual and nonhomosexual mentally retarded males in the treatment of the nose. Goldworth (**32**) found no significant differences between normals, neurotics, schizophrenics, and brain-damaged patients in drawing the nose. However, he did find that schizophrenic and normal men apparently tend to draw conflict indicators on the male nose

more often than schizophrenic or normal women.

Contact features

Contact features are the legs and feet and the arms and hands. Machover feels (**55**, pp. 59–60) that children and young adults will show more movement in their drawings than will older people because they are physically more active. As individuals grow older, Machover feels that the representation of movement in the drawings tends to decrease just as the physical activity of people tends to decrease with age. In people in whom effective contact with the outside world has been weakened, such as in neurotic or psychotic patients, the contact features will be weakened. The figures may have stiff arms and legs, or weak, poorly developed arms and legs in which the arms are held stiffly at the sides rather than extending out toward the environment.

Arms and hands. The arms and hands are felt to be "weighted with psychological meanings referring primarily to ego development and social adaptation" (**55**, p. 60). It is with the arms and hands that the individual feeds and dresses himself, either caresses or hurts other people, and maintains contact with the environment. Arms extending out to the environment in a warm, accepting fashion indicate good relationships with the environment. Machover feels that the direction of the arm placement is important in determining the contact of the individual with the environment. She feels that "in general, the direction and fluency of the arm lines relate to the degree and spontaneity of extension into the environment." She feels that omission of the arms should never be considered an oversight. Schizophrenics or extremely depressed subjects may omit the arms as an indication of withdrawal from the environment. She notes that sometimes the arms of the female may be omitted by males, in which case it suggests that the male has been rejected by his mother, and has felt unaccepted by contemporary females. She notes that the hand is the most frequently omitted feature in the drawing and the implication of missing hands or hands that are vague or dimmed out suggests the lack of confidence in social contacts or in productivity or both.

Holzberg and Wexler (**44**) found that normal women significantly more often have the hands and arms present in the drawing than schizophrenic women, more frequently had the arms placed behind the back, more frequently had line emphasis on the outline of the arms, more frequently had the arms bent at the elbows, and more frequently shaded the arms. This, of course, suggests more conflict indicators were present in normal women than in schizophrenic women. However, the authors point out that their normal group was made up of girls who probably still had not completely resolved their adolescent conflicts related to contact with other people. Probably this difference is more a reflection of the fact that schizophrenics' drawings tend to be empty and lacking in detail, whereas the drawings of normals contain more detail and therefore would probably contain more conflict indicators.

Goldworth (**32**) found statistically significant differences between normals, neurotics, psychotics, and brain-damaged Ss in the drawing of the arms and hands. He found that normal Ss predominantly drew arms on their figures that were scored "accurate." The normals drew arms-

that were correctly proportioned. Normals usually drew their arms in motion or in a natural pose. Normal men tended to redraw the arms of the female figure, making changes in the size of the arms. Normal women tended to do much erasing on the arms of the female figure. Normal *S*s rarely omitted the arms from the female figure or drew reinforced lines in the arms of the female figure. Normals also rarely omitted the arms on the male figure, but they drew more reinforced lines and did more erasing on the arms of the male figure than did any other group.

Goldworth found that the neurotics also tended to draw arms that were scored "accurate" but not quite as frequently as did the normals. Neurotics rarely drew arms that were disproportionate. Neurotics drew arms that were rigid, or dangling, more frequently than did normals, and drew fewer arms that were in motion or in a natural pose than the normal *S*s did. Neurotics rarely omitted or reinforced the arms, and shaded or erased the arms *less* frequently than any of the other groups.

Schizophrenics drew arms that were scored as "accurate" less frequently than the normals and neurotics. One-fifth of the schizophrenics drew arms scored "distorted." They drew disproportionate arms more frequently than the normals and neurotics. They drew arms that were rigid and lacking in muscle tone more frequently than any of the other groups. Schizophrenics omitted the arms and reinforced the lines in the arms more frequently than any of the other groups.

Brain-damaged *S*s rarely drew arms that were scored "accurate." They drew well-proportioned arms less frequently than any other group. Their arms were drawn dangling more frequently than those of any other group. They tended to draw many size changes on the female arms, and tended to draw somewhat fewer reinforced lines, erasures, and shading on the arms of the female figure than did the other groups.

Normal *S*s rarely drew distorted hands, but one-third of them attempted to hide the hands. Normals drew well-proportioned hands more frequently than any of the other groups. The normals had more shading and erasures in the hands than any of the other groups.

The neurotic *S*s drew more distorted hands than the normals, and did not hide the hands as frequently as the normals. They tended to draw well-proportioned hands, but not as frequently as did the normals. The neurotics did less shading and erasing than did the normals, but they made more changes in the size of the hands than the normals did.

Schizophrenics drew hands scored as "accurate" about as frequently as the neurotics, and omitted the hands no more frequently than the neurotics did. They drew fewer well-proportioned hands than the normals. The schizophrenics erased less and drew less shading in the hands than the normals, but they redrew the hands, changing the size, more often than the normals.

Brain-damaged *S*s rarely drew hands that had good accuracy and they rarely evaded drawing the hands. They drew fewer well-proportioned hands than any of the other groups. The brain-damaged tended to change the size of the hands more frequently than did the normals.

Woods and Cook (**85**) noted that there was an *r* of .43 (significant at the .01 level) between drawing proficiency and the tendency of eighth-grade students to draw the hands be-

hind the back. Woods and Cook interpret this as indicating that as a student gets more proficient at drawing he becomes aware that drawing the hands is difficult and thus has a tendency to avoid drawing them. This suggests that a tendency to hide hands goes with normality and increased maturity. This seems to agree with the findings of Goldworth which are mentioned above.

On the negative side, Holzberg and Wexler (**44**) found no significant difference between normals and schizophrenics in poor proportion of arms (which does not agree with Goldworth), the drawing of very short arms, the drawing of very long arms, arms held at a distance from the body, arms held over the head, arms held in front of the body, arms perpendicular to the body, and arms misplaced in relation to the shoulders. They also found no significant difference in the drawings of muscular arms or in the hiding of hands or in the drawing of distorted hands or line emphasis or shading in the hands. De Martino (**25**) found no significant differences between homosexual and nonhomosexual mentally retarded males in the drawing of the arms or the hands. Gutman (**40**) found no significant differences between patients who improved and patients who did not improve in therapy in the drawing of arms or hands. Royal (**67**) found no significant difference between normals and neurotics in drawing figures with missing or hidden hands, or in the relation of the man's arms to the body or of the woman's arms to the body. As noted earlier Prater (**66**) found no significant differences between hemiplegics and normals in the drawing of the arms.

The fingers. According to Machover (**55**, p. 63), the fingers are ex-tremely important in the experiential pattern of the person since they are the real contact points between the individual and the environment. Also they are important as the parts of the body that involve manipulation. Therefore she feels that grape-like fingers, though common in children, are generally indicative of either poor manual skill or infantility when found in adults. And she feels that shaded fingers or reinforced fingers are generally indicative of guilt. Speared or talon-like fingers indicate aggression and are considered to be paranoid features. She feels that the clutched fist, when held away from the body, indicates aggressive behavior which is fairly close to being acted out. When the clutched fist is held close to the body, it indicates inner repressed rebellion that is probably expressed in symptoms rather than in overt behavior. The mitten type of hand is also associated with repressed aggression, but is more evasive and noncommittal, generally being manifested by occasional outbursts of aggression rather than by symptoms. Abnormally long fingers in a drawing that is generally regressed suggest people who have "shallow, flat, and simple types of personality development." Hands that are drawn with more than five fingers on them suggest that the drawer is an aggressive, ambitious individual. Fingers that have the joints and nails carefully indicated suggest obsessive control of aggression. This is also true of drawings in which the fingers are formed like a claw or a mechanical tool.

There are few data relative to these hypotheses. Holzberg and Wexler (**44**) found that hebephrenic schizophrenic women had significantly fewer poorly proportioned fingers than normal women. Gutman (**40**) found that there were no significant differences

between the patients who improved in therapy and patients who did not improve in therapy in the drawing of useless or confused fingers. Fisher and Fisher (28) found that speared fingers were not present in a majority of paranoid patients' drawings. De Martino (25) found no significant difference between homosexual and non-homosexual mentally retarded males in the drawing of the fingers.

The legs and feet. The legs and feet are not only contact features, but also bear the responsibility of supporting and balancing the body and of moving the body about. Therefore, Machover feels (55, p. 65) that drawings showing nonexistent or weak legs and feet indicate an individual either unable to get about or having an uncertain footing or foundation. The legs of the female figure have sexual significance. If they receive conflict treatment in the form of reinforcement, erasures, or changes it suggests conflict in the sexual area. The foot may be a phallic symbol. An individual who draws a foot that looks like a phallus may be sexually inadequate and/or sexually preoccupied. Conflict treatment of the foot, such as erasures, lengthening, shortening, changing the line, or shading, suggest conflict in the sexual area. The foot may have aggressive implications, since it is an organ for propelling the body forward as well as an instrument for attack.

Goldworth (32) found that there were significant differences among his groups, in the accuracy with which they drew the legs. Four-fifths of the drawings of legs by normals were well proportioned. Normals were more accurate, particularly in the drawing of the female leg. There were a few distorted legs among the figures drawn by neurotics. Schizophrenics' drawings, he found, were much like those of the neurotics both in the accuracy of the legs and the proportion of the legs, but he did note that schizophrenics somewhat more frequently drew distorted legs than neurotics did. The brain-damaged group drew the greatest number of distorted legs, and rarely drew accurate legs. He found that there was a slight tendency for normal men to be less accurate than women in drawing the feet. Therefore, he made comparisons only between the drawings of men. He found that there were significant differences (.09 level of confidence) among the four groups in the drawing of the male feet and a significant difference (.02 level of confidence) in the drawings of the female feet. He noted that normals omit the feet as they did the hands more frequently than any of the other groups. Neurotics' drawings of the female figure are very similar to those of normals, but neurotic men do not omit the feet on the male figure as often as normal men do. This is because neurotic men tend to draw smaller male figures, and thus have enough room at the bottom of the sheet of paper for drawing the feet, whereas the normal men often draw a large male figure and do not have enough room at the bottom of the sheet of paper to get the feet on. Schizophrenics did not differ noticeably from neurotics. The brain-damaged drew the highest proportion of distorted feet. He found no significant differences among the four groups in the proportionate size of the feet. He found that there were significant sex differences in the female figure; he noted that schizophrenic women rarely drew conflict indicators on the feet, while schizophrenic men did a great deal of shading, erasing, and reinforcing compared to the women. Schizophrenic

men more frequently reinforced, erased, or shaded the feet of the female figure than men in other groups. There were no significant differences between the groups in shading, reinforcing, or redrawing the feet on the male figure.

Holzberg and Wexler (44) found that normal women significantly more often drew both legs and feet on their drawings than schizophrenic women, which is contrary to Goldworth's findings. Their normal women significantly more often drew very small, pointed feet on the drawings than schizophrenic women. The normals significantly more often than the hebephrenic schizophrenics drew the legs, drew a knee joint, and drew very small pointed feet. However, when the normal women were compared with the paranoid schizophrenics, it was found that the only significant difference was that the normals significantly more often used line emphasis on the outline of the legs. There were no significant differences between the groups in legs drawn off the bottom of the page, locked or closed legs, poorly shaped and disproportionate legs, stick legs, excessively short legs, or excessively long legs, shading the legs, naked feet, delineation of toenails, poorly formed feet, excessively large feet, penis-like feet, single-dimensioned feet, shading the legs and feet, or line emphasis in the outline of the feet or shoes.

Toes. According to Machover (55, p. 67), when toes are indicated in a figure that is not intended to be a nude they are regarded as an accent on aggressiveness that "is almost pathological in nature." Holzberg and Wexler (44) found no significant differences between normals and schizophrenics in drawing naked feet with the toes indicated, or in drawing feet with the toenails delineated.

Miscellaneous Body Features

The trunk. Machover states (55, p. 68) that the trunk is often limited to a simple oblong, a square box, or a circular unit. She suggests that round figures are drawn by individuals who are passive and have feminine characteristics, whereas square trunks are drawn by masculine persons. The bottom of the trunk is left open in some drawings. Machover suggests that this indicates sexual preoccupation. Drawing an especially thin trunk on the figure of the same sex as the *S* is suggested as indicating that the subject is discontented with his body type. In the case of a thin individual, the thin trunk is a direct representation of body weakness, and in a heavy individual the thin trunk suggests "compensation for unwelcome rotundity."

Goldworth (32) found that normal men drew the trunk with greater accuracy significantly more often than normal women. He also found that there were significant differences between normal men, neurotic men, psychotic men, and brain-damaged men. He observed that practically all normals drew trunks that scored at the "excellent" or "adequate" accuracy level. No normals scored at the "primitive" or "distorted" level. Neurotics drew few extremely good trunks and several drew distorted trunks, but no neurotics drew primitive trunks. Schizophrenics drew trunks that resembled those drawn by neurotics, but the schizophrenics drew primitive and distorted trunks more frequently than neurotics. The brain-damaged drew "primitive" trunks more frequently than the other three groups. Goldworth found that there were no significant differences between his four groups in the proportions of the male trunks they drew. There were significant differ-

ences between the four groups in proportions of the female trunks they drew. Normals drew female trunks that were correctly proportioned. Most of the grossly disproportioned female trunks were drawn by schizophrenics and brain-damaged patients.

Holzberg and Wexler (44) found the only difference between normal women and schizophrenic women was that the normal women significantly more often drew shading in the chest and waist areas of their figures. There were no significant differences between normals and hebephrenic schizophrenic women in any of the body characteristics, but normal women significantly more often shaded the chest than the paranoid schizophrenic women.

Royal (67) found in comparing his neurotics with normals that the neurotics tended to draw the head and trunk in a rectangular or circular s♦ ♦e significantly more frequently th. ♦ normals. There was no significant difference between the two groups on the shading of the body.

Breasts. According to Machover (55, p. 69), the most consistent emphasis on breasts is noted in the drawings of the emotionally and psychosexually immature male. This sort of emphasis is generally found to consist of erasures, shading, or the addition of lines. Machover feels that it is important whether the breasts on the figure are the low, pendant sort of breasts typical of a mother-figure, or the high, firm breasts of the youthful female figure. She notes that the female who draws large breasts and a well-developed pelvis on her female figure is strongly "identified with a productive and dominant mother-image. . . ."

Holzberg and Wexler (44) found that normal women significantly more often than schizophrenic women delineated the breasts and shaded the chest. When the subgroups were compared no significant differences between normal women and hebephrenic schizophrenic women were found, but the normal women significantly more often delineated the breasts than the paranoid schizophrenic women. There were no significant differences between the normals and the schizophrenics in drawing a very narrow chest, drawing a nude breast or breasts, in the line emphasis on the outline of the chest, or delineating the nipples on the breast.

Goldworth (32) found that breast emphasis was found primarily in the drawings of neurotic subjects.

Shoulders. According to Machover (55, p. 71), the width and massiveness of the shoulders are the most common graphic expression of physical power and perfection of physique. In drawings by males massive shoulders emphasized at the expense of other parts of the figure are generally drawn by adolescents and sexually ambivalent individuals as an overcompensation for feelings of body inadequacy. A female S who draws massive shoulders on the female figure may be suspected of having some degree of masculine protest. Massive shoulders on the figure of the same sex as the S indicate that the S feels physically inadequate.

Holzberg and Wexler (44) found that normal women significantly more often had shoulders present on their drawings than did schizophrenics. When the schizophrenic group was split into paranoid and hebephrenic subgroups and compared with the normal group, it was found that normals significantly more often drew broad shoulders, had shoulders present in the drawings, and emphasized the lines of the outlines of the shoulders than did hebe-

phrenic schizophrenics. Normals significantly more often drew broad shoulders than did the paranoid schizophrenics.   Kotkov and Goodman (47) found that obese females drew square shoulders more often than normal weight females. Goldworth (32) found there were no significant differences among his groups of male Ss in drawing the shoulders. However, he found that there were significant differences among his female groups. The normal women made many more erasures than did any of the other groups, and showed far fewer instances of omission, shading, or changing the size of the shoulders. He found that neurotics occupied a score position intermediate between the normals on one hand and the schizophrenic and brain-damaged on the other hand. The schizophrenic and brain-damaged women tended to have few erasures but had many omissions, and much shading or size changes on the shoulders of the female figure.

These studies provide no clear-cut test of Machover's hypotheses, but they suggest that the shoulders may have more significance for female Ss than for male Ss.

Hips and buttocks. According to Machover (55, p. 72), emphasis on the hips and buttocks is characteristic of homosexually inclined or homosexually conflicted males. This may be indicated by confusion, a break or change in the line, a particular widening or other conspicuous treatment of the buttocks. In female figures drawn by females exaggerated hips indicate that the woman is aware of the power that relates to the "functional potentialities of ample pelvic development."

Goldworth (32) found no significant differences between males and females in treatment of the buttocks;

however, he did find significant differences between normals, neurotics, psychotics, and brain-damaged people. He found that normal individuals had the fewest conflict indicators in the drawings of male hips, while the brain-damaged showed the greatest number of conflict indicators on both the male and female hips. The neurotic drawings tended to fall midway between the drawings of normals and the drawings of the brain-damaged in the number of conflict indicators found in the hips.

No studies report a comparison of the drawings of hips by homosexual males with drawings of hips by nonhomosexual males. This seems rather strange since this hypothesis would seem to be a fairly clear-cut and easy one to test.

Waistline. The waistline serves to separate the "above" part of the body from the "below" part of the body (55, p. 72). In the man the "above" part is the chest area which embraces the primary body features of physical strength. The "below" part refers to the area of sexual functioning. In the female the "above" part refers primarily to the breasts and nutritional factors, whereas the "below" part in the female refers to the sexual and reproductive functions. The legs of the female also are related to the sexual allure of the girl; therefore, adolescent girls "being at the threshold of adult sexuality," show the greatest amount of leg conflict.   Machover feels that conflict in the waistline may be expressed by a delay in drawing the waistline, by a reinforced waistline, by a broken line at the waistline, by an elaborate belt drawn at the waistline, or by an excessively tightened waistline.

Holzberg and Wexler (44) found that normal women significantly more often than schizophrenic women

shaded the waist area. When comparing the schizophrenic subgroups with normal women, they found no significant differences between normal women and hebephrenic schizophrenic women, but found that normal women did shade the waist area significantly more often than paranoid schizophrenic women; and also that normal women had an "absence of straight vertical lines for the waist" significantly more often than paranoid schizophrenic women. However, there were no significant differences between normal women and schizophrenic women in line emphasis on the outline of the waist.

De Martino (25) found no significant difference between homosexual mentally retarded males and nonhomosexual mentally retarded males on shading of the waist.

Anatomy indications. According to Machover (55, p. 74), internal organs are not drawn in the DAP except by schizophrenics or actively manic patients. However, Holzberg and Wexler (44) found no significant difference between normal and schizophrenic women in the representation of internal organs. Few Ss in either group drew internal organs on their figures.

Machover feels that the inclusion of sexual organs in a drawing is not generally found except in the drawings of professional artists, people who are under psychoanalysis, and schizophrenics. But in this regard, too, Holzberg and Wexler (44) found no significant difference between normal women and schizophrenic women in any representation of the genitals, or in line emphasis or shading in the genitals.

Joints. Machover states that the drawing (55, p. 75) of joints suggests a faulty and uncertain sense of body integrity. She feels that this sign is found chiefly in schizoid and schizophrenic individuals.

Holzberg and Wexler (44) found that normal women showed the knee joints significantly more often than hebephrenic schizophrenic women. There were no significant differences between the normal and schizophrenic women in the representation of knuckles. These results are a direct contradiction of Machover's hypothesis.

Clothing

Machover feels (55, p. 75) that "it is generally accepted that clothes always have some libidinal significance." She feels that clothing is essentially a compromise between modesty and body display, and that most subjects tend to draw a vague indication of clothing. She feels that a person who asks whether or not he should draw a figure with clothes on it may be assumed to be troubled by a strong body self-consciousness. Often the identity of the drawn figure can be inferred from the clothes. For example, a male drawing a figure with clothes appropriate for the 1920's suggests that the S identified with his father. She also states that a small proportion of Ss tend to underclothe or overclothe their drawings. The overclothed figure is drawn by a "clothes-narcissist." The clothes-narcissist is a superficially quite sociable and extroverted individual, but this sociability is motivated primarily by a desire for social approval and dominance rather than by an interest in people. Those who underclothe the figure are called by Machover "body-narcissists." Body-narcissists tend to display muscle power and tend to be schizoid and introverted.

Holzberg and Wexler (44) noted that normal women had a significantly greater tendency to draw

clothing on their figures than did schizophrenic women. When the schizophrenics were broken down into subgroups, they noted that normal women significantly more often than both the hebephrenic and paranoid schizophrenic women drew figures in which there were clothes. Paradoxically, Holzberg and Wexler also report that normal women drew figures which were nude significantly more often than the paranoid women. There were no significant differences between the normal women and the schizophrenic women in the drawing of minimal clothing, in having inadequate clothing represented, or in having a special emphasis on more-or-less unusual clothing items such as jewelry. Normal women significantly more often than schizophrenic women drew a figure with a wide skirt. There were no significant differences between the two groups in the drawing of shoelaces, high heels, gloves, or overcoats.

Structural and Formal Aspects

Action or movement. Machover states that action is more commonly found in the drawings of males than in the drawings of females (55, p. 85). Drawings obtained from psychiatric hospital patients tend to be static. A figure which conveys an impulse to movement that is blocked is most often drawn by schizophrenics who have strivings toward actions that are blocked.

Holzberg and Wexler (44) found no significant differences between normals and schizophrenics in action portrayed in drawings. There were no significant differences between the groups on figures running, figures sitting, figures kneeling, or bending. Royal (67) found no significant differences between normals and neurotics in movement portrayed by the figure.

Goldworth (32) found that normals drew the arms in motion more frequently than his other groups. Neurotics drew substantially fewer figures with the arms in a natural motion than did the normals. Schizophrenics had drawings that were similar to those of the neurotics, with the exception that the schizophrenics more frequently drew "floating figures." (This refers to figures who do not "have their feet on the ground.")

Succession. Most normal people draw a figure with some sort of systematic succession. It is suggested (55, p. 86) that people suffering from an impulse disorder, such as manic excitement or schizophrenic thinking, work in confusion, scattering all over the drawing without any particular plan. On the other hand, the compulsive individual will tend to develop each area quite carefully and in detail bilaterally. Holzberg and Wexler (44) found no significant differences between normals and schizophrenics in a tendency to begin a drawing on one part of the page and then start someplace else on another part of the page, turning the page over, etc.

Mid-line. Mid-line emphasis may be indicated either by a line down the middle of the body or by an elaborate treatment of the Adam's apple, tie, buttons, buckle, or the fly on the trousers. Machover feels (55, p. 89) that such emphasis indicates somatic preoccupation, feelings of body inferiority, emotional immaturity, and mother-dependence.

Holzberg and Wexler (44) found that their normal women significantly more frequently than schizophrenic women emphasized the mid-lines of their drawings. When the normals were compared with the hebephrenic schizophrenic subgroup, it was found that the normal women significantly

more often than the hebephrenic women emphasized the mid-lines. However, no significant difference was found between the normal women and the paranoid schizophrenic subgroup.

Size and placement. It is felt (**55**, p. 89) that a figure that is placed on the right side of the page indicates a subject who is environment-oriented, while a figure placed on the left side of the page suggests a subject who is self-oriented. A figure placed high on a page suggests optimism, while a figure placed low on a page suggests pessimism. Large figures suggest high self-esteem and high energy level, whereas small figures suggest low self-esteem and a low energy level; or, as Machover states in the case of regressed schizophrenics, a small figure is an expression of "a low energy level and a shrunken ego." Grandiose paranoid individuals tend to draw large figures which suggest high self-esteem. Individuals suffering paranoid conditions associated with alcoholism or senility, in which the self-esteem is low, may draw a figure which is small in size but high up on the page, the position of the figure on the page suggesting the optimism characteristic of these individuals. Large figures may also be drawn by the aggressive psychopath. However, Machover feels that the psychopath will draw his large figure on the left side of the page, which indicates that he not only has high self-esteem, but also suggests the inadequacy he feels.

Cramer-Azima (**22**), in her study of the drawings of a man under ACTH treatment for beryllium-dust poisoning, noted that when the patient was meek and depressed, at the beginning of treatment, he drew a figure that was about $3\frac{1}{4}$ inches high. After twenty-one days of treatment the patient was showing signs of euphoria and later became grandiose. At this time, his figure was $8\frac{1}{2}$ inches tall. After the discontinuation of treatment, when the patient's behavior became less euphoric and expansive, he drew a figure $6\frac{1}{2}$ inches tall. In this case, the size of the figure seemed to increase as the subject became more euphoric, and the figure became smaller as he became less euphoric. Gutman (**40**) noted that patients who improved in therapy tended to draw figures that were more than four inches tall. Patients who did not improve in psychotherapy tended to draw figures that were less than four inches tall. Lehner and Gunderson (**50**) found that men tend to draw larger figures the older they get, until they get to 30 years of age. Beyond 30 years of age, men tend to draw figures smaller and smaller. Women tend to draw larger figures, the older they get, until they reach age 40. Beyond age 40, women tend to draw gradually smaller figures. This could be interpreted as a reflection of the self-evaluation of the individuals; that is, as a man grows older and more capable, he tends to draw larger figures, but as he passes the "prime of life" and begins getting older and less able, his figures become smaller. Kotkov and Goodman (**47**) found that obese women tended to draw figures that covered more horizontal area on the page than did normal weight women.

On the other hand, Goodman and Kotkov (**35**), in their study of obese women, did not find any significant relationship between insecurity and a tendency to place the figure on the upper left-hand side of the page. Fisher and Fisher (**28**), in their study of signs on the DAP which differentiate between paranoids and normals, used as one of the signs of paranoid

schizophrenia the size of the drawing. In their study they were unable to significantly differentiate between normals and paranoid schizophrenics using this sign. Gutman (**40**) found no significant difference between patients who improved in psychotherapy and those who did not improve in psychotherapy in the tendency to draw their figures on the left side of the page. Holzberg and Wexler (**44**) found that normal women tended to draw figures that were small or constricted in size significantly more often than schizophrenic women. They found that normal women tended to draw small figures significantly more often than the hebephrenic subgroup, but that they did not draw small figures significantly more frequently than the paranoid schizophrenic subgroup. There were no significant differences between the normals and schizophrenics in a tendency to draw very large figures or in the placement of the figures on the page. The evidence presented here is conflicting. A carefully controlled definitive study of these hypotheses should clear up some of the conflict.

Stance. The stance in drawings (**55**, p. 92) is regarded as meaning the same thing as the stance of a real person. A figure in which the legs float off into space may be drawn by an individual with precarious stability. This kind of figure is supposed to be drawn, for example, by older chronic alcoholics. A stance in which the legs are closely pressed together suggests a tense, self-conscious, and repressed individual. In a female figure this is suggested as "a fear (or repressed wish?) of sexual attack." It is suggested that when this is seen in the female figure drawn by a male subject, he anticipates resistance to sexual advances.

Goldworth (**32**), found significant differences between his groups in the stance of their figures. He found that normals usually drew figures which had a "normal" stance. No normal subjects drew figures that lacked equilibrium or were floating. The neurotics tended to draw fewer figures in a natural motion or pose than did normal *S*s. Several of the figures drawn by neurotics lacked equilibrium. However, floating figures were rarely drawn by the neurotics. Schizophrenics' drawings tended to be quite similar to the drawings of neurotics with one major exception: there were a substantial number of floating figures drawn by schizophrenics. The brain-damaged subjects drew the least number of figures which had a definite equilibrium, and the largest number of figures which were floating or lacked equilibrium. Over one-third of the drawings by the brain-damaged group were either floating or lacked equilibrium.

Gutman (**40**) found no significant difference between the DAP's of those who improved in therapy and those who did not improve in therapy when compared for stance. However, when stance was combined with a tendency to draw the same sex larger, it was found that those patients who improved in therapy tended to draw figures with a firm, assertive stance and drew the same-sex figure larger than the opposite-sex figure significantly more often than did the group of patients who did not improve in therapy. When stance was combined with the position of the legs as a sign, it was found that patients who improved in therapy tended to draw figures with a firm, assertive stance, and with the legs side by side, in parallel, significantly more frequently than patients who did not improve in therapy. However, an assertive stance when com-

bined with pressure of the lines of the drawing did not differentiate significantly between patients who improved and patients who did not improve.

Fisher and Fisher (28) were unable to differentiate significantly between normal women and paranoid schizophrenic women using rigid stance as a sign of paranoid schizophrenia. Royal (67) found no significant difference between normals and neurotics in the inclination of the figures from the vertical axis.

Perspective. It is felt (55, p. 93) that drawing the figure in profile indicates evasiveness. But drawing a figure from the front view does not necessarily indicate accessibility or frankness. Machover states that boys and men draw a figure in profile more frequently than girls or women do. This suggests that females are more sociable and are more accessible to clinical contact than are men.

Cramer-Azima (22) noted that when her subject, being treated with ACTH for beryllium-dust poisoning, was behaving in a rather expansive and euphoric manner he drew his figures facing forward. In the other drawings, when he was inclined to be more depressed, tense, and anxious, he tended to draw the figures facing sideways. Royal (67) found no significant difference between anxiety neurotics and normals in the direction they drew the men's or women's heads facing. Holzberg and Wexler (44) found no significant difference between normal women and schizophrenic women in having one part of the body in profile and the other part of the body in front view.

Type of line. The line delineating the contour of the body is felt to be the wall between the body and the environment (55, p. 95). Machover feels that chronic schizoid alcoholics

and others suffering from fears of depersonalization or from acute conflict over withdrawal trends may draw a heavy, thick line as a barrier between themselves and the environment. She feels that "the body wall is built as a substantial structure as though to ward off an attack of the environment and to guard securely the contents of the body." She feels that the apprehensive neurotic individual may also draw heavy lines for the same reason. In such a drawing, conflicts which are aroused by drawing special areas in the figure will be expressed by a sudden change in the line or a gap in the line. Dim lines are most frequently drawn by timid, self-effacing, and uncertain individuals. The dim line may be sketched or fragmented. Also, a body drawn with such a line may have uncertain contours and individual parts of the body may be blurred. Drawings in which the contour of the head is heavy and reinforced while the facial features are dimly sketched suggests that the drawer is an individual with a strong desire for social participation, but who is shy and timid and self-conscious in actual social expression. Lines which fade in and out with spotty reinforcement are suggested as being drawn by people given to hysterical reactions. In these cases, the head and facial features may be well delineated while the body is blurred, and the arms and legs fade away into random lines. The very faint, "ectoplasmic," line does not appear very often, and when it does it is generally drawn by withdrawn schizophrenics. Acutely excited schizophrenics generally draw very heavy lines. Broken or tremulous lines are generally drawn by the schizoid alcoholic, who is distinguished from the paranoid alcoholic who tends to draw the figure with a heavy line.

Gutman (**40**) found that patients who did not improve in psychotherapy tended to draw continuous and reinforced lines. Patients who did improve in psychotherapy tended to draw their figures with light or sketchy lines. Royal (**67**) found no significant difference between normals and anxiety neurotics on pencil pressure, continuity of lines, regularity of lines, single-line and multiple-line drawings. Holzberg and Wexler (**44**) found no significant difference between normal females and various kinds of schizophrenic females in the use of very light lines throughout the whole drawing, in the use of light lines in parts of the drawing, in the use of fragmented or broken lines in all of the drawing, or in the use of broken lines in just parts of the drawing.

Conflict Indicators

Erasures. Erasures are a form of conflict treatment and are most apt to be noticed in the hands and feet, the shoulders, the arms, the nose, the ears, the crotch, and the hipline. Interpretation depends on the part of the body in which the erasure is found. This form of conflict treatment is felt by Machover (**55**, p. 98) to be seen primarily in neurotics, obsessive compulsive characters, and psychopaths with neurotic conflicts. Erasures are considered an expression of anxiety but differ from line reinforcement and shading in that they show overt dissatisfaction. She states that pubertal girls erase profusely.

Royal (**67**) found no significant difference between his normal men and his anxiety neurotic men in erasures. Holzberg and Wexler (**44**) found that normal women tended to erase significantly more often than paranoid schizophrenic women, but that there was no significant difference between normal women and hebephrenic schizophrenic women in this regard. Goldworth (**32**) found that, in general, normals drew more conflict indicators, both erasures and shading, than did other groups. He notes that, in the case of the hands, arms, ears, and hips, neurotics tended to show the least number of conflict indicators. In the case of the shoulders, the neurotics tended to show fewer erasures than the normals, but more erasures than the schizophrenic or brain-damaged patients. In the case of the nose, the neurotics show fewer erasures than either normal men or schizophrenic men.

These results appear to contradict Machover.

Shading. Shading as an indicator of conflict has already been partially considered in connection with the discussion of the particular parts of the body, but some of this discussion will be repeated here. According to Machover (**55**, p. 98) shading is an indication of anxiety. The particular area shaded suggests the source of the anxiety. Vigorous, aggressive scribling to cover up something is considered to be a discharge of aggression and an expression of concealment. The most frequent kind of shading is done by using light, dim, and uncertain lines which accent particular parts of the figure. The most frequently shaded parts of the figure are the chest of the male figure, which Machover feels indicates sensitivity to physical inferiority, and the breasts of the female figure done by the male *S*, which suggest conflict concerning mother dependence. Female subjects may put a few subtle lines in the skirt in the area of the genitals suggesting "furtive and inhibited sexual concern."

Goldworth (**32**) summarized his findings on this topic by stating that

the normals' drawings contained the least number of conflict indicators, including shading, of any group on only three scales: the male and female ears, and the male hips. On all the other parts of the body, he found that the normals showed proportionately the same amount of conflict indicators as other groups. He found the brain-damaged group consistently drew the largest number of conflict indicators.

Holzberg and Wexler's (44) findings regarding shading of particular parts of the body have already been presented in relationship to other parts of the body. Briefly these results will be repeated here. Normal women significantly more frequently than schizophrenic women tended to shade the following parts: mouth, arms, chest, and waist. Normal women did not shade any parts significantly more often than the hebephrenic schizophrenic subgroup. However, normal women did shade the following parts more frequently than the paranoid schizophrenic subgroup: mouth, hands, chest, and waist.

Royal (67) found no significant differences between normal men and anxiety neurotic men in the shading of the hair or of the body and clothing. Gutman (40) found no significant difference between patients who improved in therapy and patients who did not improve in therapy in the amount of shading on the figure. De Martino (25) found no significant differences between male homosexual mental defectives and male nonhomosexual mental defectives in the shading of the waist, arms, legs, or other body parts. The results seem to indicate that normals show at least as much shading, on most body parts, as any group of abnormal Ss.

Differential treatment of male and female figures. Machover hypothesizes (55, p. 101) that the individual who is identified with his own sex will draw the self-sex figure first. She states that "some degree of sexual inversion was contained in records of all individuals who drew the opposite sex first . . . ." She also feels that Ss who scramble the sexual characteristics of the two figures they draw are suffering from sexual maladjustment. A pair of figures in which one figure is drawn disproportionately larger than the other suggests that the larger figure is viewed as the stronger, while the smaller figure would suggest that the figure drawn smaller is the weaker sex.

Barker, Mathis, and Powers (8) compared a group of 50 homosexual soldiers with a control group of 35 normal soldiers on the sex of the first drawn figure. They found no significant difference between the two groups. Hammer (41) found no significant difference between homosexual offenders in Sing Sing Prison and two groups of nonhomosexual offenders in the sex of the first drawn figure. Granick and Smith (37) found no relationship between the sex of the first drawn figure and scores on the masculinity-femininity subscale of the MMPI. De Koningh (24) found no significant relationship between sex of the first drawn person and sexual differentiation as measured by Swensen's (76) scale which is described below.

Swensen (76) developed a scale for rating sexual differentiation between the male and female figures on the DAP. Using this scale to measure sexual differentiation, he found that normals drew figures in which the differentiation between the male and female figures is significantly better than that of either neurotics or psychotics. Sipprelle and Swensen (70)

used this scale and three other sexual indicators on the DAP in an effort to determine the relationship between the DAP and the *S*'s sexual adjustment. They found no significant relationship. Cutter (23) used Swensen's scale to compare the sexual differentiation of normals, neurotics, and psychiatric patients suffering from severe personality disorganization (psychotics, alcoholics, etc.). He used as *S*s 108 sexual psychopaths under observation at a state hospital, 59 sexual psychopaths committed to the hospital who were receiving psychotherapy, 22 psychiatric technician trainees who served as a control group, a group of 19 neurotics and a group of 17 suffering from "personality disorganization." The "personality disorganization" group was composed of "alcoholics, psychotics in remission, etc." He found that there were no significant differences between the different groups of sexual offenders, and that the sexual offenders did not differentiate between the sexes of the figures on the DAP any worse than the normals. However, he did find that the group of overt sexual offenders differentiated between the sexes on the DAP significantly better than the group of neurotics or the group suffering "personality disorganization."

Fisher and Fisher (29) related the femininity of the female figure drawn by 76 female psychiatric patients to the sexual adjustment of these patients. The femininity of the female figure was rated on a four-point scale. They rated the *S*s on the following indices: general femininity, subjective satisfaction from sexual relations, range of past heterosexual experience, somatic sexual dysfunction, and bizarre sexual manifestations accompanying the onset of mental illness. Of 54 computed statistics, only

8 were significant at the .05 level. They reported that women who drew figures of low femininity tended to have had fewer heterosexual experiences than the other *S*s, had more dysfunctions of the sexual organs, and had led constricted sex lives. Those who drew the most feminine figures tended to have had more promiscuous but unsatisfying sexual experiences. The *S*s drawing figures of intermediate femininity reported more satisfaction from their sexual experiences.

Singer (69) attempted to test Machover's hypotheses relative to the projection of sexual conflict on the DAP. Singer hypothesized that in our culture pubescents should suffer more sexual conflict than prepubescents. He used a group of 18 pubescents matched with a group of 18 prepubescents for age, IQ, school grade, and socioeconomic status. He obtained DAP's from both groups and analyzed them by an "analytic" method using signs obtained from Machover, and also analyzed them by a "holistic" method in which he judged the drawings as a whole rather than by paying attention to specific parts of the drawings. His techniques did not significantly differentiate between the drawings of the pubescents and the drawings of the prepubescents.

None of the studies cited above provides evidence to support Machover's hypothesis concerning the significance of the sex of the first drawn person on the DAP. Only one of the studies cited suggests that particular sexual characteristics of drawings are related to the sexual adjustment of the *S*s, and that one study (29) reports only 8 of 54 computed statistics significant at the .05 level. In view of the results reported by the other studies, it seems reasonable to sug-

gest that the results reported by Fisher and Fisher (29) were due to chance.

Summary Table of Findings

For the purposes of illustration and discussion, the author prepared Table 5 to illustrate in a very rough way the conclusions the studies cited suggest concerning Machover's hypotheses about the significance of the content and structural and formal aspects of the DAP. It is not claimed that the table is entirely objective. If the reader prepared a table of his own it would probably come out slightly different from that presented here. But it does suggest that no considerable empirical support for Machover's hypotheses exists at the present time. Perhaps the most charitable thing that can be said for the hypotheses concerning the content and the structural and formal aspects of the DAP is that few of Machover's hypotheses have been explicitly tested by definitive studies. But those which have, such as her hypothesis concerning the

sex of the first drawn figure, have not been supported by the experimental evidence.

DISCUSSION AND CONCLUSIONS

Evaluation of the DAP as a Clinical Tool

The evidence presented in this paper does not support Machover's hypotheses about the meaning of human figure drawings. More of the evidence directly contradicts her hypotheses than supports them. And, even in the studies where some support for her hypotheses can be found, many of the cases did not render the human figure drawings in the way that would be expected according to Machover. For example, Berman and Laffal's (10) study found a significant relationship between the body type of the S and the body type of the figure drawn by the S, but a majority of the Ss did not draw figures that were of the same body type as the S. Since in clinical work the reliable diagnosis of the individual case is of paramount importance, this lack of

TABLE 5

RESULTS OF COMPARISON OF EXPERIMENTAL RESULTS WITH MACHOVER'S HYPOTHESES CONCERNING BODY PARTS AND STRUCTURAL AND FORMAL ASPECTS OF THE DAP

Supported	Conflicting Evidence	Not Supported	Not Tested[a]
Neck	Facial Expression	Head	Chin
	Mouth	Ears	Eyebrow
	Lips	Nose	Trunk
	Eye	Legs and feet	Shoulders
	Hair	Fingers	Hips and buttocks
	Hands and arms	Toes	Clothing
	Waist	Anatomy	Pockets
	Buttons	Breasts	Tie
	Action	Joints	Shoe and hat
	Size	Succession	Theme
	Stance	Mid-line	Symmetry
	Perspective	Placement	
	Type of lines	Erasure	
		Shading	
		Sexual treatment	

[a] Items were included in this column if the reported research did not appear to test Machover's hypotheses, or if no research concerning them was reported in literature. Those for which no research is reported have been omitted from the previous discussion.

consistent evidence supporting Machover, on both the group level and the individual level suggests that the DAP is of doubtful value in clinical work.

On the other hand, many clinicians routinely use the DAP and feel that it is a valuable tool. Machover wrote her monograph on the basis of extensive clinical use of the DAP which convinced her that it was a valuable instrument. This "clinical evidence" needs to be considered.

The discrepancy between the results of research studies and the testimony of people with extensive clinical experience may stem from the fact that the two figure drawings obtained in the DAP, as it is usually administered, do not provide enough data for making a reliable assessment of personality dynamics in most cases. This conclusion is suggested by Caligor's study (18), in which he found that paranoid trends could be detected in only 25% of a group of paranoid schizophrenics when only one drawing was used but could be detected in 85% of the cases when a series of eight drawings was used. Although two drawings are not sufficient basis for the reliable diagnosis of most individuals, they can provide data that may be sufficient for the accurate diagnosis of some cases. Once in a while the clinician meets a client who draws figures that clearly illustrate his problem. For example, the Casper Milquetoast-type client who draws a small, weak-looking male figure, and a towering, overbearing, scowling female figure who bears a remarkable resemblance to the patient's wife. The clinician will probably remember this case long after he has forgotten twenty Casper Milquetoasts who did not draw a weaklooking male figure and a powerful female figure. Since cases which do illustrate pretty clearly the dynamics

of an individual case are more likely to stick in the memory of the clinician than cases which do not, this possibly explains why clinicians feel that the DAP is of value in clinical work, and also explains the sources of Machover's hypotheses.

But even though there is much evidence which does not support the use of the DAP in clinical work, there still may be a place for it. If, as has been suggested above, the nonsignificant results obtained in using human figure drawings are primarily because two drawings do not provide enough data for reliable diagnosis, figure drawings may still be of some value as one part of a diagnostic battery composed of several different kinds of test and behavioral data. And when it is used as a part of a diagnostic battery, it should be kept in mind by the clinician that the DAP, by itself, does not provide sufficient evidence for a diagnosis, but that the DAP must be considered in conjunction with other instruments. The DAP is easily and quickly administered, which is one advantage in using it as one type of data to be considered along with all of the other data obtained from the psychological test battery.

Another use for the DAP might be as a rough screening device, or as an indicator of "level of adjustment." That is, although it may not provide enough data for diagnosing the various factors or aspects of personality dynamics in the individual case, it may be useful as a device for screening large groups of people, or as a rough gauge of how well the individual patient is functioning. Several studies that have been previously cited (23, 32, 44, 78, 83) have reported significant differences between groups of normal Ss, neurotic Ss, psychotic Ss and brain-damaged Ss on many different aspects of the DAP. Margolis (58) and Cramer-

Azima (22) have reported changes in the DAP which were concomitant with changes in the adjustment of the individual Ss. Also, Modell (62) studied the changes in the DAP's of 28 hospitalized regressed psychotics as they improved in adjustment. He gave the DAP to these patients serially during their course of treatment at the hospital. The DAP's of these patients were rated, using a scale devised by him, for "body image maturation" and "sexual maturation." On the "body image maturation" scale the immature body is represented by an oval. The mature body is a trunk or pelvis that resembles in shape that of a normal human being, with clothing and other pertinent details present. On the "sexual maturation" scale the drawing with immature sexual characteristics has few or no details which differentiate between the male and female figures. The drawing with mature sexual characteristics has male and female figures which can clearly be identified as male and female. In his study he found that as a patient recovered from regressed states, the "sexual maturation" and the "body image maturation" of their DAP's improved significantly. Albee and Hamlin (1, 2) obtained DAP's from 10 patients representing a wide range of emotional adjustment, and had 15 clinical psychologists rate the drawings, using the paired-comparisons technique. The judges judged which of the pair of DAP's was from the better adjusted S. By comparing each DAP with every other DAP they obtained a mean preference score for each DAP. The Ss were rated for emotional adjustment, the ratings based upon the patients' case histories. The rank-order correlation between the rating of the drawings and the rating of the case histories was .62, which is significant at the .05 level. Albee and Hamlin (2) then used the drawings mentioned in the previous study as a scale with which they rated the drawings produced by 21 outpatients diagnosed as schizophrenics, 21 outpatient anxiety cases, and 30 dental patients. These cases were controlled for age, sex, education, and veteran status. It was found that the scale differentiated reliably between the normals (dental patients) and each of the outpatient groups, but did not differentiate between the schizophrenics and the neurotics.

But even though the evidence cited above suggests that the DAP might be used as a gross indicator of "level of adjustment," it still needs more precise evaluation for this purpose than any study has so far provided. As Meehl (61) has pointed out, it is possible for a test to significantly differentiate between two groups, and still be useless or worse than useless in making predictions in the individual case.

Suggested Approaches to Future Research

Research designed to systematically test the validity of a particular theoretical system is probably more likely to yield useful results than research randomly testing unrelated hypotheses. Since Machover's system of interpretation is probably going to continue to be used in figure-drawing analysis until a more valid system is proposed, future research is most apt to be fruitful if it is designed to test specific hypotheses of Machover's. It must have been evident to the reader, in the presentation of the studies reviewed in this paper, that few of the studies reported were designed to test specific hypotheses of Machover's.

Studies which attempt to evaluate

the significance of patterns of signs on the DAP appear to be more promising than attempts to evaluate the significance of individual DAP signs. This is suggested by the results obtained by Goldworth (32) and Gutman (40). This, of course, has been pointed out by Machover (55, p. 21).

Studies are needed in which DAP's are taken, serially, from Ss while the Ss are undergoing treatment. Such studies, if they included adequate control groups, should throw some light on those aspects of the DAP which vary concomitantly with variations in the Ss' behavior.

Caligor's Eight-Card-Redrawing Technique (17, 18, 19) appears to be quite promising for research purposes. He developed this technique in an effort to get at factors that were buried too deeply in the unconscious to be revealed by the standard DAP method. In the Eight-Card-Redrawing Technique (usually shortened to 8 CRT) the S is given a pad with eight sheets of onion-skin paper in it. He is asked to draw a full-length picture of a person. After he has completed his first drawing the next sheet of onion skin is folded over the sheet upon which he has made his first drawing, and he is told to draw another picture of a person, making any changes he wishes to make. In this way he may see his first drawing through the transparent onion skin while he is drawing the second figure. When the second figure is completed a sheet of cardboard is put between the first drawing and the second drawing. A third sheet of onion skin is folded over the second sheet, and he is again asked to draw a new figure, making

any changes he wishes to make from the second figure. This is repeated until the S has drawn eight figures. While he is drawing each figure, except the first, he is able to see the drawing he has just finished. If, as Caligor suggests, this technique taps more reliably various personality factors, it would appear to be worthwhile to use it to explore the significance of various gross and fine details of the DAP.

A series of carefully planned, statistically sophisticated studies of the reliability of the various parts of the DAP are especially needed. Not only should the reliability of the individual parts and aspects be determined, but the reliability of patterns should also be studied. It would probably prove quite fruitful to factor-analyze the DAP in an effort to determine its basic dimensions.

SUMMARY

1. Machover's hypotheses concerning the DAP have seldom been supported by the research reported in the literature in the past eight years.

2. It is suggested that the opinion of clinicians that the DAP is of value as a clinical instrument, despite the lack of experimental evidence to support this judgment, is due to the fact that the DAP, in a few cases which impress the individual clinician, does provide an indication of the nature of the individual client's problems.

3. Some evidence supports the use of the DAP as a rough screening device, and as a gross indicator of "level of adjustment."

4. Approaches to future research are suggested.

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ON PREDICTION IN SKILLED MOVEMENTS[1]

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No attempt will be made to give a detailed account of the role of prediction in a large number of specialized manual skills. Instead there will first be a discussion of prediction in a single activity, pursuit or two-pointer tracking in one dimension. Then it will be shown how similar principles are involved in many everyday skills.

PURSUIT TRACKING

Pursuit tracking has two aspects which are common to a number of skills. First, it involves the acquisition of a moving target, as when an operative picks an object off a moving conveyor belt. Reaching for a stationary object can be regarded as a special case of this more general form of acquisition. And, second, pursuit tracking involves matching a function relating position and time, as in following a moving object with binoculars. Most of the other common examples of this kind of matching differ in two ways from conventional tracking: the task is self-paced, instead of paced by the movement of the target; and the path of the target can be seen ahead. In some cases it is the target path whose movement has to be controlled, as in following a

contour with a sewing machine or power-operated fretsaw. In other cases the operative moves along a stationary target path, as in steering a car in traffic or along a winding road, following the contour of a window pane with a paint brush, and tracing the contours of a picture with a pencil.

Pursuit tracking in one dimension can be recommended as a task for study in the laboratory on two counts. First, the target movement or input can be varied along a psychological dimension from simple and repetitive to more complex and irregular. Two other dimensions of target movement, frequency and amplitude, can also be varied independently. And, second, both the input and the response can be recorded as wavy lines on the same moving paper tape, since they are restricted to a single spatial dimension. This record can then be analyzed in a number of different ways, and, as Craik has shown (5, 6), the nature of the match or mismatch between the response and the input enables us to specify some of the psychological processes which are involved in the performance.

We shall not discuss rotary-pursuit tracking, for it has neither of these advantages. The input is fixed; and the only measure which is normally taken of the performance is whether *S*'s stylus is touching the target area or not. Ammons (1) has described in detail the techniques of the different experimenters in this field. We shall also not consider compensatory or one-pointer tracking, for it demands more complex computations than are required in most other manual skills. A compensatory display shows *S* only an error function, which is the resultant of the input and his response movements. He receives no direct indication of the input, and the only direct

indication of his response movements comes from the kinesthetic and other bodily sensations which they produce (31).

The rapid acquisition of a stationary target. A rapid aiming movement which is completed in about .5 sec. cannot contain a voluntary correction, for a voluntary movement has a reaction time (RT). Under the optimal condition where S is ready and waiting for the signal for the movement, this RT is about .2 sec. Similarly, the voluntary correction of a movement also has a RT. Vince's results on the reactions to pairs of successive signals suggest that the sooner the voluntary correction is made after the initial movement, the longer this RT will be (40, Table 1). Hick has shown that when S is half expecting to have to make a voluntary correction, and the signal which indicates that a correction must be made occurs as he starts his initial movement, the correction has a RT of about .3 sec. (21). If we add the .2-sec. latency of the original aiming movement to the .3-sec. latency of the voluntary correction, we obtain a total delay of .5 sec. This is the minimal time after the signal for an aiming movement, at which a voluntary correction of that movement could start to become effective. The commencement of a voluntary correction even as soon as this, assumes that S was more or less prepared for it, and took the decision at the time that the original aiming movement began, before the movement got under way.

It follows that a rapid aiming movement should be unaffected by visual monitoring, for there is no time to use this visual information. This hypothesis has been tested by Taylor and Birmingham (see 3, pp. 1–2) who used an oscilloscope display and a single practiced acquisition movement. They compared three conditions: (a) visual monitoring of the response on the oscilloscope; (b) an unexpected failure of visual monitoring—the position of the spot on the oscilloscope was unaffected by the response; and (c) an unexpected reversal of the normal control-display relationship, such that the usual response made the spot move in the opposite direction. They found that in all three conditions the characteristics of the movement of the first attempt at acquisition were the same, although in condition c this movement was followed in due course by a response in the correct direction.

The decision to make a rapid aiming movement thus involves a prediction. As it were, S says to himself: "if I contract such and such muscles to such and such an extent, I will end close to the target." This appears to be the most elementary form of prediction shown in skilled movements. It will be called *effector anticipation*, and is listed in the top row of Table 1. The more obvious forms of prediction discussed later can be looked upon as extensions of this elementary form. To many psychologists this may not appear to involve prediction at all, only simple learning. But the point is that the use of any learning involves prediction of a kind. In a familiar situation S makes a particular response because in some sense he "knows" from his past experience that it should turn out to be correct.

In the rapid acquisition of a stationary target some over-all time for the muscular contractions has also to be specified. But this time is not critical unless S has been told that he must acquire the target as rapidly as possible, or at some particular instant. For the sake of brevity and simplicity of exposition, we shall not consider these special cases. We may simply note that by suitable experimental procedures it would no doubt be possible to produce situations which would require subdivisions of the relatively simple broad classifications which we are going to present.

TABLE 1

PREDICTIONS REQUIRED IN PURSUIT TRACKING

Task	Predictions	Name
Acquisition Rapid acquisition of a stationary target	(a) Prediction of nature and size of muscular contractions required	Effector anticipation
Rapid acquisition of a moving target whose future track is displayed ahead	(a)+(b) Prediction of duration of response movement	Receptor anticipation
Rapid acquisition of a moving target whose track is controlled by known constants or statistical properties	(a)+(b)+(c) Prediction of future position of target at time of completion of response movement	Perceptual anticipation
Matching Matching the movement of a target whose future track is displayed ahead	(1) Prediction of nature and size of response adjustment required +(2) Prediction of duration of response adjustment	Receptor anticipation
Matching the movement of a target whose track is controlled by known constants or statistical properties	(1)+(2)+(3) Prediction of future movement of target at time of completion of response adjustment	Perceptual anticipation

A rapid aiming movement may be followed by one or more voluntary corrections, as it becomes clear that the present movement will not hit the target exactly. These voluntary corrections are often beautifully illustrated by records from step-tracking experiments, such as those of Vince (**40**, Fig. 3), Searle and Taylor (**37**, Fig. 3), Ellson and Wheeler (**14**, Fig. 2), Craig (**4**, Fig. 2), and Slack (**39**, Fig. 2). In addition, a rapid aiming movement may involve several corrections at the level of the spinal reflex. For as Woodworth has pointed out (**42**, p. 116), the knee jerk, which is one of the classical instances of a reflex correction, has a latency as short as .03 to .04 sec. It is only voluntary movements with which this paper is concerned.

The lengthening of the RT to the second of a pair of signals has been called "psychological refractoriness." Welford (**41**) has cited the evidence for this phenomenon up to 1950, and since then there have been papers by Elithorn and Lawrence (**10**) and Davis (**7**, **9**), and also some comments on the Elithorn and Lawrence paper (**6**, **22**). Refractoriness can be demonstrated under two distinct conditions, which are often confounded (**28**): (a) The *S*

may not expect the second signal; (b) the second signal may follow the first so closely that he has no time to prepare for it, whether he expects it or not. Aiming responses made without adequate preparation also tend to be less accurate than well-prepared aiming responses (**28**, p. 104; **33**, Table 1).

The rapid acquisition of a moving target. As has been pointed out by Young (**43**), this is a more complex process than acquiring a stationary target, because the target will have moved before *S* has completed his response movement. For acquisition to be accurate, he has therefore to know in advance the position which the target will occupy at the time his response movement finishes. In addition, as with a stationary target, he has to make a prediction about the nature and size of the muscular contractions required to reach this point. There are two possible sources of in-

formation which can be used to determine the future position of the target.

First, the future track of the target may be displayed ahead. Examples are certain laboratory tasks which simulate a simplified form of driving. Thus in one experiment (**32**, harmonic tracking task), *S* was given a ball-point pen which could be moved against a transparent bar. He had to keep the point on a curved line drawn on a paper tape. The tape moved at a constant speed at right angles to the bar, and the curved line on it could be seen for varying distances ahead of the bar. Accurate acquisition is possible in these circumstances, provided *S* can predict how long his response movement will take. For he can then aim at the point ahead which the target will have reached as his response movement is completed. This whole procedure has been called *receptor anticipation* (**30**, p. 222), because the receptor mechanism has to function ahead of the response mechanism. It is listed in the second row of Table 1. Receptor anticipation may be looked upon as a special case of the more general receptor-effector span, such as the eye-hand span in touch-typing from copy. It is a special case because it involves more accurate judgments of timing than are usually required.

Second, the future track of the target may not be displayed ahead, but the track may contain constants or statistical properties which are known to *S* from past experience (**31**, **35**). Thus the target may be traveling in a predictable direction at a predictable rate. Examples are aiming just ahead of an object which is traveling at a familiar speed, in order to pick it off a moving belt or rotating table, when the object can be seen but the belt or table is screened from view. For acquisition to be accurate under

these conditions, *S* has to make the two predictions mentioned previously, and one additional prediction. He must now predict the position which the target will occupy as his response movement is completed. The whole procedure has been called *perceptual anticipation*, to distinguish it from the rather simpler receptor anticipation (**30**, pp. 222–223). It is listed in the third row of Table 1.

Matching the movement of a target. Matching the movement of a target without a response lag can be looked upon as the continuous acquisition of a moving target. It is the more general case, of which a discrete acquisition is a special instance. The predictions required are similar to those discussed above, and are listed in the bottom half of Table 1.

If matching were carried out by a series of rapid acquisition movements, *S* would be in alignment approximately every .5 sec., but between these times he might be ahead of or behind the target. In practice, when receptor or perceptual anticipation is possible in pursuit tracking, the experienced *S* tends to match the rate of movement of the target, or even its acceleration. If he matches the target rate, he adjusts the rate of his movement to match the known or predicted rate of the target at the predicted time at which his decision will have been carried out. He may at the same time attempt to correct a small mismatch in position, by selecting a rate slightly greater or less than the known or predicted rate of the target. But if the target has a constant rate, Ellson, Hill, and Gray have found that small misalignments may continue for several seconds at a time, although there is virtually no mismatch in rate (**13**). This is one line of evidence that the practiced *S* can match the rate of the target.

Another line of evidence comes from Elkind (11, p. 43), who used noise inputs with various spectral shapes and cutoffs. With most inputs he found that the magnitude of the closed-loop transfer function increased at high frequencies. This, he stated (11, p. 41), "is characteristic of systems that respond to input derivatives." Additional evidence is supplied by Senders (38), who appears to have used inputs composed of two sinusoids. He found that display conditions which supplied the greatest amount of information about the target rate tended to give the best time-on-target scores.

In pursuit tracking with a simple harmonic input of 60 c.p.m., a difference in phase or amplitude, or a constant error in position, between the target and response pointers was sometimes found to have arisen gradually (34). When the difference became large enough, it was corrected. Somewhat similar results have been reported by Noble, Fitts and Warren (27). These errors can be looked upon as due to more or less constant mismatches in various rate functions. They suggest that S was predominantly matching the acceleration of the target, and was neglecting small differences in rate until they resulted in appreciable errors in position.

The nature of the tracking performance immediately following a blink (which completely obscures vision for about .25 sec. [23]) also suggests that S can respond to the acceleration of the target (36, p. 65). For theoretical errors calculated on the following two assumptions—(a) that S stopped initiating any movement while blinking, and (b) that he stopped initiating any change in rate of movement while blinking—were in both cases much greater than the observed errors.

However, when Gottsdanker (16, 17, 18) instructed his Ss to extrapolate accelerating and decelerating target movements, he found that they extrapolated the rate at which the target moved a little before it disappeared, but not its acceleration or deceleration. This was presumably due to lack of adequate practice with knowledge of results (KORs). For after only two practice runs with each course under a condition which could have afforded KORs if S had been aware of it (16, tracking a completed course), some response to acceleration was found. In a more recent review (19) Gottsdanker wrote as if he might be aware of this criticism, although he did not mention it. For he outlined a program of research on the perception of acceleration.

Where it is possible to match the acceleration of the target reasonably accurately, the mean tracking error is likely to be reduced. For a small error in acceleration produces initially only a small difference in rate between the two pointers. This difference in rate has to be left uncorrected for a time before it results in an appreciable error in position.

When the acquisition of a target is to be followed by matching, the two processes may be blended together. Instead of acquiring the target as quickly as possible, S can acquire the target more gradually. He may move at a rate which is intermediate between the fastest possible rate of acquisition, and the present rate of the target. Such a compromise reduces the acceleration component in the response. As we say, it makes the performance smoother. But smoothness is achieved at the price of a slightly greater error averaged over time. The use of these compromise responses in pursuit tracking is shown clearly when the two-pointer display is made invisible for a period of time. For on the reappearance of the display S is often confronted with a quite considerable discrepancy between the positions of the two pointers. In these circumstances it has been found that the practiced S generally makes a compromise response (34, p. 191).

Matching with an average lag of practically zero has been reported in pursuit tracking when the future track of the target was visible ahead (**32**, Table 3). A view of the track for .4 sec. ahead was found to be about as effective as a view for 8.0 sec. ahead. But a view for only .3 sec. ahead resulted in a significant increase in mean lag. Ellson and Gray (**12**, Figs. 2 and 3) found a mean lag (or negative phase shift) of practically zero in pursuit tracking with predictable simple-harmonic inputs of either 30 or 60 c.p.m. In this case there was no preview of the target track. A certain amount of practice is required before the mean lag is reduced to practically zero under these conditions (**30**, Fig. 4).

If the track of the target is neither displayed ahead nor predictable, S's responses will tend to be at least one RT behind the target. In these circumstances he has two extreme courses of action open to him. Either he can attempt to follow the track of the target more or less exactly, but with a relatively large and consistent lag. Or he can attempt to reduce the mean lag to his RT, by reacting as quickly as possible to each obvious discrepancy between the positions of the two pointers. This latter course of action reduces the mean error, but also reduces the smoothness of the response record. In practice, the mean performance of a group of Ss lies somewhere between these two extreme courses of action (**32**, Table 3).

EVERYDAY SKILLED MOVEMENTS

Smooth complex movements. Prediction plays an important role in smooth complex movements. We will consider first a complex movement which does not have to fit the environment at all, e.g., drawing the letter "S" in space. The S does not have to wait until he has completed the first component of such a movement (whatever a component is taken to be), before he initiates the next component. For he knows from previous experience the approximate position he will have reached at the end of the first component, and the approximate time it will have taken him. He therefore initiates the next component, which will carry him on from this point, before he has ever reached it. He can thus make a single smooth movement, instead of a succession of simpler movements separated by short pauses.

Two predictions are involved for each component of such a smooth complex movement. First, a prediction has to be made as to where the component will end. If the movement is regarded as aiming at a series of imaginary targets, this prediction can be put the other way around: S has to predict the nature and size of the muscular contractions required to reach the imaginary target which is the endpoint of the component. And, second, he has to predict the time at which the endpoint will be reached. These predictions are listed in the fourth row of Table 2. A good deal of practice is needed, both in order to ensure that each component movement is made with sufficient precision to have a suitable and reasonably predictable endpoint in space and time, and so that S can learn the range within which this endpoint will fall. In our example of drawing an S, most of this practice presumably occurred on first going to school.

A smooth complex movement of this kind can be called a *closed skill without external requirements.* The term "closed" was selected (**29**, p. 4) because the performance can be carried out successfully without reference to the environment. A somewhat analogous verbal task is rehearsing to oneself an overlearned sequence of words or nonsense syllables. (A closed skill does not need to be a single smooth complex movement. Thus a succession of taps, each separated

TABLE 2

Movement	Prediction	Name	Analogous Verbal Task
Discrete aiming	(*a*) Prediction of nature and size of muscular contractions required	Open skill without advance information	Reading aloud a word on a memory drum
Variable smooth complex	(*a*) + (*b*) Prediction of duration of each component	Open skill with advance information	Reading aloud from manuscript
Relatively invariant smooth complex	(*a*) + (*b*) + (*c*) Prediction of future requirements	Closed skill with predictable requirements	Reciting aloud
Relatively invariant smooth complex	(*a*) + (*b*) only.	Closed skill without external requirements	Rehearsing silently
Aiming with amendment	(*1*) Prediction of unsuccessful outcome of present response (*2*) Prediction of future position and movement of responding member in one RT (*3*) Prediction of nature and size of response adjustment required at this point	Open skill with exacting positional requirements	Amending the pronunciation of a difficult foreign word

by periods of inactivity, may also be a closed skill without external requirements. But in this paper we are concerned with periods of more or less continuous movement, not with periods of inactivity.)

A closed skill can be made to fit the environment, provided the requirements are not too exacting, and can be predicted in advance. An example is dealing a pack of playing cards into four piles. This can be done by almost any experienced player with his eyes closed. For he has only to ensure that the cards land face downwards, that each pile receives a card in turn, that the piles are located on the table, and that they do not run together. Except for these restrictions, the exact position of each card does not matter, and the task is unpaced.

A closed skill of this kind can be looked upon as the more general case, of which a closed skill without external requirements is a special instance. The same two predictions have to be made about each component as in a closed skill without external requirements. And, in addition, a prediction has to be made about the requirements of the environment. These predictions are listed in the third row of Table 2, under the title "Closed skill with predictable requirements." Certain of the imaginary targets of the closed skill without external requirements have simply become real. Practice is again necessary. Reciting aloud an overlearned sequence is a somewhat analogous verbal task.

Lincoln (26) has published a study in which one condition involved the learning of a closed skill with predict-

able requirements. This study dif-
fered from our example of dealing a
pack of cards, in that it was the rate
of a movement which had to be
learned; the nature of the movement
can be looked upon as either prede-
termined or irrelevant. A handwheel
had to be turned for periods of 15 sec.
at a rate of 100 r.p.m. In the relevant
condition the only knowledge of re-
sults was given at the end of each
period, when S was told his average
error. Lincoln found that, after the
first few trials, Ss trained in this way
performed as accurately as Ss who
had the additional advantage of see-
ing all the time how their rate of
turning deviated from the required
rate. Another study used pursuit
tracking with a simple-harmonic in-
put of 60 c.p.m. (**34**). In this case
both the nature and the rate of the
movement had to be learned. It was
found that, after a relatively short
learning period, S could sometimes
respond for 5.0 sec. with his eyes shut
without any appreciable effect upon
his performance.

A closed skill with predictable requirements
needs to be checked intermittently against
the environment. This is because with the
passage of time the performance tends gradu-
ally to drift in its positioning and/or timing
from the optimal requirements. The less
exacting the requirements are, and the more
practiced the S is, the longer will be the time
for which the skill can proceed without a
check. In the two examples we have just
considered, the performance only proceeded
for 15.0 and 5.0 sec. respectively before a
check was made. In the case of tracking with
the eyes shut, an error in phase had generally
developed by the end of the 5.0 sec., as a
result of a small error in wave length (**34**,
p. 192).

Closed skills may be contrasted
with *open skills*. An open skill is a
skill which has to fit either an unpre-
dictable series of environmental re-
quirements, or a very exacting series,
whether predictable or unpredictable.
Provided (*a*) that the unpredictable
series of requirements is not too ex-
acting, (*b*) that each requirement is
presented either before S is ready for
it, or before it needs to be considered,
and (*c*) that the requirements are not
separated by spells of inactivity, a
smooth complex movement can still
be made to fit the series after prac-
tice. For once S has apprehended the
next one or more requirements, he
can proceed in the same fashion as in
a closed skill with predictable require-
ments. The two predictions involved
are listed in the second row of Table
2, under the title "Open skill with ad-
vance information." Reading aloud
from a manuscript is a somewhat
analogous task.

There are certain characteristic dif-
ferences between a closed skill with
predictable requirements and an open
skill with advance information. Leon-
ard found that with a four-choice
self-paced task, an open skill with ad-
vance information could not be per-
formed as rapidly as the comparable
closed skill (**25**). He attributed this
to the need to take in the advance
information in the open skill. On the
other hand, when the relative timing
of the responses (or changes in re-
sponse) was all important, a condi-
tion which allowed S to see the future
requirements all the time resulted in
greater speed and accuracy than con-
ditions in which the future require-
ments had to be remembered, or de-
duced from previous requirements
(**35**).

Serial aiming movements. The re-
quirements of the environment may
be relatively unexacting, but the next
requirement may not be presented
until S is ready for it, and it needs to
be considered immediately. In this
case the aiming movement which

corresponds to each requirement must be separated from the aiming movement which corresponds to the next requirement by a pause at least as long as an RT. Each aiming movement is similar to the rapid acquisition of a stationary target in tracking. The only prediction involved is thus of the nature and size of the muscular contractions needed to hit each target. This type of movement is listed in the first row of Table 2, under the title "Open skill without advance information." An analogous verbal task is reading single words presented one at a time on a memory drum. (If *S* has been instructed to respond as quickly as possible after the presentation of the signal, the over-all time for the muscular contractions has also to be included in the prediction. For simplicity of exposition this special case is not covered by Table 2.)

Leonard (**24**) has compared open skills with and without advance information. He used both a two-choice task in which movements were constrained to a triangular path, and a four-choice task with a free-moving stylus. In both tasks *S* was instructed to work as fast as he could, while making as few errors as possible. Leonard found that with advance information the component movements tended to merge into each other; more time **was** spent on moving and less time on pausing. Whereas without advance information the component movements tended to be separated by pauses; less time was spent on moving and more time on pausing. Thus greater smoothness was possible with advance information. Leonard noted (**24**, p. 148) that to appreciate this difference fully it had to be observed, or, better still, experienced. The changes in move-

ment time were smaller than the changes in the time spent on pausing, and hence the tasks were also performed rather more quickly with advance information.

When the positional requirements of the environment are more exacting, two or more aiming movements may be needed for each target, owing to the residual noise in the response system. With a relatively unpracticed *S*, these successive movements may be separated by RT's. They are thus similar to the discrete aiming movements which we have just discussed. But with practice the successive aiming movements tend to merge into each other, so that it is often difficult to tell exactly where a movement would have ended if it had not been amended (**33**, p. 99).

The amendment of a movement to make it hit a target involves a number of predictions. First, *S* had to predict that the movement will not hit the target without amendment. Secondly, when he is about to amend the movement, he has to predict approximately where his responding member will be in one RT, and what it will then be doing. And finally, he has to predict the nature and size of the change in movement which is required at this point in order to hit the target. These predictions are listed in the bottom row of Table 2, under the title "Open skill with exacting positional requirements." Amending the pronunciation of a difficult word in a foreign language is an analogous verbal task. (A prediction related to the duration of the amending response has also to be included if *S* is working as quickly as possible.)

An open skill with exacting positional requirements employs a relatively variable sequence of components in order to achieve a

highly precise endpoint. It can be contrasted with a closed skill, which employs a relatively invariant sequence of components, but achieves only a less precise endpoint. This is because the closed skill does vary to some extent, and this variation is not corrected as is the case in the open skill.

Mixed movements. Different parts of a cycle of operations may demand different degrees of precision. Where great precision is not necessary, the successive parts which are related to known requirements can be welded into a single, smooth, complex movement. But a part which demands great precision will always tend to need some additional aiming. Thus a cycle of operations may involve both smooth complex movements and serial aiming movements.

An example of a mixed movement is given by Golby, Annett, and Kay (15). They recorded the performance of practiced Ss carrying a peg 8.0 in. and putting it into a hole, by means of high-speed cinematography. The Ss had to work as quickly as they could. As the size of the hole was reduced, the time taken by the first 7.5 in. of the carrying movement was found to remain practically constant. It was only the time taken by the last .5 in. of the movement which increased appreciably (15, Fig. 1). In our terminology, the first 7.5 in. of the movement was an open skill with advance information, or even a closed skill with predictable requirements, while the last .5 in. was an open skill with exacting positional requirements.

Golby, Annett, and Kay also employed the contact method of recording movements, which has been used extensively by Smith and his collaborators (20). As the size of the hole was reduced, this method showed an increase in both the movement-loaded and the positioning components of the task (15, Fig. 1). Clearly this method of recording confounded the low-precision carrying stage with part of

the final high-precision aiming. In view of these findings, the authors claim that the cinematograph method of recording movements can give the greater insight into their nature, even though it does involve a good deal more work in analyzing records.

Most of the sensorimotor skills of industry must start at the beginning of training as a series of aiming movements. Where an operation needs great precision, or where a requirement cannot either be learned or apprehended in advance, there is a limit to the amount of smoothing which is possible. But where less precision is necessary, and the requirements can be learned or apprehended in advance, each series of aiming movements may become in time a single, smooth, complex movement.

Closed and open have been used in a different sense from the closed and open loops of the electrical engineer. In the engineer's terminology, both closed and open skills involve closed loops within the effector mechanism, i.e., kinesthetic feedback, at least at the level of the spinal reflex. If we consider the over-all input-output relationship, only the open skill with exacting positional requirements necessarily works closed loop on the input, and here there is a delay in the feedback loop corresponding to S's RT. All the other skills listed in Table 2 with external requirements may work open loop on the input for longer or shorter periods of time. Our distinction between closed and open skills corresponds to Campbell's distinction between "body-consistent" and "object-consistent" responses respectively (2, p. 334). In his paper, Campbell has discussed the relationship of this distinction to other theoretical viewpoints.

SUMMARY

Table 1 shows three kinds of acquisition which have been studied in the field of pursuit or two-pointer tracking. It also lists the predictions which have to be made in order to carry out each task successfully, and suggests names. Matching a moving target is a more general case of the acquisition of a moving target. In-

stead of simply matching positions, the practiced S tends to match rates or even accelerations.

Table 2 presents a classification for everyday skills. It also shows the pre-dictions which are needed in each case, and suggests a terminology. Many manual operations probably contain as components two or more of the kinds of skill listed.

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THE PSYCHOPHARMACOLOGY OF LYSERGIC ACID DIETHYLAMIDE (LSD-25)

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A great deal of interest has been directed recently to the use of drugs as an aid to understanding and establishing a biological or chemical mechanism for the so-called functional psychoses, specifically, schizophrenia. Although no irreversible demonstrable organic or chemical change has as yet been demonstrated for schizophrenia, there is renewed interest in the possibility that new biochemical and physiological methods are available which are more sensitive and can consequently be employed to ascertain subtle changes which previously had eluded investigators searching for a biological fundament. It is claimed (49) that although toxic psychoses and endogenous psychoses are not identical, still, there is significant similarity with regard to clinical aspects and subjective symptoms to furnish psychiatry with a controllable toxic state within the nervous system that permits investigation of the endogenous psychosis. Solms (46) ventures still further and discusses the possibility that schizophrenia is due to a toxicosis because of this apparent similarity between the behavior engendered by certain drugs and the endogenous psychosis.

The rationale of this approach in studying the functional psychoses is difficult to establish logically. At first it is observed that there are some features common to schizophrenia and the behavior of nonpsychotics intoxicated with a drug. Then, there occurs the gradual identification of the two states by most authors who assume that all elements of the two domains are identical. It should be pointed out that no studies to date have been conducted to establish the identity of these two processes. One searches the literature in vain to find a study requiring a psychiatric team to evaluate and classify a population consisting of previously diagnosed schizophrenics and those under the influence of some "psychotomimetic" drug which concludes that the population was homogeneous or undifferentiable. However, in spite of the fact that the processes have not been shown to be identical, still there are behavioral manifestations of a toxicosis that resemble aspects of the syndrome that characterizes schizophrenia. It is the brave hope of workers in this area that new chemical and biological advances will be made that will permit a greater understanding of the functional disturbances which will result in effective prophylactic and therapeutic procedures.

PSYCHOLOGICAL EFFECTS

Of the numerous chemical substances that have striking effects on man's behavior, mood, and mental processes, there is one that has been employed most frequently, lysergic acid diethylamide (LSD-25), an indole derivative belonging to the class of ergot alkaloids.

The profound behavioral changes occasioned by LSD intoxication in normal human beings or nonpsychotics have led numerous investigators to call it a psychotomimetic agent, apparently because of the striking similarity they observed be-

tween schizophrenic behavior and the behavior induced by LSD. With a dose as small as 20–50 μg., it has been reported (7, 13, 47) that normal subjects manifest euphoria with compulsive laughter, depression, and some degree of confusion. In some cases there are visual illusions, hallucinations resembling those caused by mescaline, disorders of coenesthesia, posture sense, and autonomic difficulties. Rinkel et al. (38) reported that psychotic phenomena and alterations of the autonomic nervous system were observed following the administration of LSD to normal subjects. The psychotic phenomena were predominantly schizophrenic-like symptoms that were manifested in disturbances of thought and speech, changes in affect, mood, and perception, production of hallucinations and delusions, as well as depersonalization. Only slight changes were produced by LSD on the EEG and these were principally an increase in the total amount of alpha rhythm. Rorschach tests showed abnormalities principally of the paranoid schizophrenic type. Concrete-abstract thinking tests showed responses similar to those obtained in schizophrenic patients. Arnold (5) found that LSD produced disturbances in the body image and regarded this change as a retrogression to an early stage of ontogenetic development, possibly due to an influence on the function of the thalamo-cortical connections. Stoll (48) administered the Rorschach test to 11 mentally normal patients with and without previous administration of LSD. Under the influence of LSD there was "a general loosening of mental processes comprising disinhibition of affectivity and fluency of thought processes; the precision and wealth of content were, however, decreased." He concluded that the mix-

ture of psycho-organic and schizophrenic traits corresponded to the clinical picture of a disturbance of the acute exogenous reaction type. Delay et al. (14) employed the Rorschach test on normals one week prior to LSD administration and during the effect of LSD (80 μg. orally). Comparison of the two tests showed that under LSD all personality features were intensified and therefore "more readily identifiable." Nevertheless, the authors state that it would be dangerous to draw conclusions as to the real personality of the subject from the findings of the test, for, "the toxic factors distort the picture of the true hypertrophy of the personality." Matefi (33) employed only one subject, a physician, to study the effects of LSD and mescaline and reported that they produced different psychopathologic reactions; the former, one of hebephrenic type and the latter catatonic. These clinical impressions were reinforced by means of a drawing test interpreted by the author. Drawings produced under the influences of LSD showed a tendency to expansion, while the "mescaline pictures" showed constriction. The drawings elicited from the subject under the influence of each drug showed "some similarity" to the drawings produced by psychotic patients. Abramson et al. (4) administered 25–225 μg. of LSD and placebos orally to 26 nonpsychotic adults and used a questionnaire containing 47 items to indicate changes in physiological and perceptual responses. They found that the characteristic feature of items to which responsiveness was affected under LSD was that they were related to autonomic functions said to be elicited by anxiety. It was of interest to read that the symptoms elicited by placebos were mostly depressive symp-

toms. Abramson et al. (2) also investigated the effect of LSD on the manual and verbal reaction time to auditory and visual stimuli employing 12 nonpsychotic subjects given 50 μg. of LSD orally and found that LSD had little effect on the manual reaction-time tests but significantly impaired the scores on the verbal reaction-time tests. Jarvik et al. (29) studied the effect of 50 and 100 μg. of LSD on arithmetic test performance employing 12 nonpsychotic adults and found that the scores varied inversely with the dose, i.e., the higher the dose the lower the score. Abramson et al. (3) explored the effect of the same doses on two tests of hand-eye coordination and found no statistically significant differences. However, Jarvik et al. (28) found that on 9 tests of recognition and recall significant impairment was found on 6 tests with a dose of 100 μg. whereas no significant impairment of either recall or recognition was manifest with a dose of 50 μg. In another experiment, he (27) evaluated the effects of LSD (50 and 100 μg. orally) and placebo on attention and concentration by means of various psychological tests, e.g., marking of particular figures in a mass of similar figures. Six out of eight tests showed no significant differences between the scores after placebo and after 50 μg. of LSD. Two tests showed a significant difference between the scores after placebo and 100 μg. LSD. The authors feel certain that had they "ruled out" the effects of practice the decrease in performance after LSD would have been even more significant.

Typically, the evidence employed to establish identity between the endogenous functional psychoses and the toxic states has been derived from studies and observations such as these. The reports may be summarized as indicating that various behavior changes which have been characterized as psychotic-like are occasioned by minute quantities of LSD, These conclusions are based either upon clinical impressions or upon uncontrolled Rorschach protocols usually obtained from small samples. The objective studies of Abramson and his associates demonstrate that some cognitive and motor functions are significantly impaired by LSD, but the pattern of impairment has not as yet been compared to that which may characterize the functional psychoses.

PHYSIOLOGICAL EFFECTS

It is only recently that studies of the electrophysiological effects of the psychotomimetic agents have been undertaken. Marrazzi and Hart (32) studied the effect of LSD on the evoked cortical response of a trans-callosal preparation that received 8 μg./kg. and found that the amplitude of the postsynaptic component of the transcallosal response was reduced. Elkes et al. (16) found that cerebral synaptic transmission in the cat is inhibited by adrenaline, amphetamine, mescaline, LSD, and serotonin. Purpura (37) studied the effects of LSD on evoked potentials in the auditory and visual systems. He found that LSD caused facilitation of the primary cortical responses to auditory and visual stimulation in cats. The cortical response to lateral geniculate radiation shock was also facilitated by LSD. Evarts et al. (17) studied the effects of LSD on synaptic transmission in the visual system of the cat. Intracarotid administration of 30 μg./kg. caused a decrease in the amplitude of the geniculate postsynaptic response to a single shock to the optic nerve.

Whereas geniculate transmission was blocked by LSD, transmission within the retina and between geniculate radiation fibers and cortical cells was extremely resistant to inhibition by LSD.

Generally, these studies have demonstrated marked differences in the sensitivity of various synapses to the blocking effects of LSD. Among the most sensitive synapses are those involved in the transcallosal and suprasylvian-striate reactions. The lateral geniculate synapse is less sensitive, whereas the synapses of the retina and those between lateral geniculate radiations and cells in the visual cortex are extremely resistant to the blocking effects of LSD.

Studies of the effects of LSD on spontaneous cortical activity in animals and in man have been reported. The results of Bradley and Elkes (8) are typical of the findings reported by other investigators who employed cats or rabbits. In the conscious, unrestrained cat from which electrical activity was recorded with implanted electrodes, LSD (15–25 μg./kg., orally) was followed by an EEG pattern which was not unlike that seen in the normal alert animal. It consisted of diffuse, low-amplitude, fast (from 15–30 counts per second) activity. The EEG of cats that had not received LSD showed higher amplitude and slower activity. Rinkel et al. (38) studied the effects of LSD on the EEG in humans and found that LSD caused only slight changes in the EEG, these changes consisting principally of slight increases in the frequency of occurrence of the alpha rhythm.

As yet, no one has attempted to relate any particular behavioral effect of a drug to a demonstrated disturbance of the electrical activity of the nervous system. It is clear that corticocortical responses are sensitive

indices of the effect of LSD, at least in animals, but the relationship between inhibition of these responses and the psychological effects of LSD remains obscure.

MECHANISM OF ACTION
Intermediate Carbohydrate Metabolism

Mayer-Gross et al. (34) hypothesized that the minute dosage required to produce the psychological effect of LSD had as its mode of action some anti-enzyme activity. Since the only substrate known to be metabolized by the brain cell is glucose, an investigation was made of the effect of LSD on carbohydrate metabolism in vivo. The increase in hexosemonophosphate and glucose suggested that there was an increased metabolism of glycogen coupled with a probable block in the breakdown of hexosemonophosphate. The changes in carbohydrate metabolism observed after the intake of LSD are considered responsible for at least part of the psychological symptoms. To test the mechanism that LSD blocked glycogen decomposition at the first phase of hexose-1-phosphate, preventing any further cleavage down to the end products pyruvic acid and lactic acid, Mayer-Gross et. al. (35) deduced that application of glucose (which is broken down directly via hexose-6-phosphate) should abolish the toxic symptoms. This seemed to be the case, according to the authors, except that the number of experiments was too small to provide conclusive evidence. Arnold (6) also investigated the correlation between subjective sensations and carbohydrate metabolism and concluded that the manner of experiencing an event may be modified by LSD because it produces a toxic disturbance affecting certain cell groups. He found that the

effect of LSD may be either interrupted or retarded for 3 to 5 hours by either glutamic acid (20–100 gm.) or by succinic acid (10 gm.). Neither glutamic acid nor succinic acid is considered a detoxifying substance; instead, they are substances which protect the organic substrate against LSD so long as their concentration in the cellular groups affected is sufficient for protection. Proceeding from the hypothesis that even in acute schizophrenia there is a disturbance in the energy metabolism of certain cell groups, the author investigated the therapeutic effects of glutamic and succinic acids. Employing dosages calculated to suppress the effects of LSD, he could favorably influence certain "labile" symptoms (impulses, passion, emotional tension, etc.) but could not influence symptoms of deficiency or alterations in personality. Fischer et al. (18) investigated carbohydrate metabolism by employing standard tests of liver function prior to and after administration of LSD and mescaline. He reported that LSD caused a less intense and transient disturbance in liver function than mescaline. Quick's hippuric-acid test was found to be negative after LSD but positive after mescaline, as it is in most cases of acute schizophrenia. However, the cinnamic-acid test of liver function of Snapper-Saltzman, which is more sensitive, reveals transient disturbances of liver function after the administration of LSD.

Buscaino et al. (9) injected two dogs with 1 and 10 μg. LSD, intravenously, and they developed, respectively, psychomotor excitement followed by depression in one case and "catatonia" in the other. In chronic experiments (4 μg. intramuscularly over 23 days, 11.8 μg. intramuscularly over 56 days, and

15.3 μg. orally over 90 days) the animals developed psychomotor excitement initially but were soon normal again. Following administration of LSD the EEG spectrum showed a shift to high frequency waves of low amplitude. Hypoglycaemia and hyperbilirubinaemia were generally noted in the chronic experiments whereas the histochemical phosphatase reactions in the brain were modified in the acute experiments. The liver and kidneys exhibited degenerative changes in the parenchyma. These findings were employed to support a hepatotoxic theory of schizophrenia.

The Pituitary-Adrenal Axis and Reaction to Stress

Hoagland and his associates (24) compared the adrenocortical function and urinary phosphate excretion of schizophrenics to normals under the influence of LSD. In normal subjects, LSD (0.5–1.0 μg./kg., orally) reduced the excretion of inorganic urinary phosphates as compared to the control values. While the subjects were under the influence of LSD, 25 mg. corticotropin markedly enhanced the excretion of inorganic phosphate. This increased excretion of inorganic phosphates under the impact of adrenocorticoids in the LSD-treated normal subjects is similar to that found in schizophrenic patients not given LSD. The findings indicate that LSD appears to stimulate the pituitary-adrenal axis and leaves the adrenals somewhat unresponsive to corticotropin. It is suggested that LSD acts on enzyme systems to facilitate the binding of phosphate. Adrenocorticoids may release the phosphate from its bound form and thus account for the marked output of urinary phosphate in schizophrenic patients and in normal sub-

jects under the influence of LSD following the action of corticoids. An endogenous derivative of adrenaline metabolism may act in schizophrenic patients in a similar manner to that in which LSD acts in normal subjects. Thus, this hypothesis proposes that schizophrenia may be due to the production of an endogenous metabolite that modifies phosphorylation. Rinkel et al. (39) also found in biochemical studies that LSD seemed to stimulate the pituitary-adrenal axis. With LSD, the adrenals were rendered somewhat unresponsive to adrenocorticotrophic hormone and modified urinary phosphate output (similar conditions prevail in schizophrenia). The authors assume that LSD interferes with the adrenaline cycle and that adrenoxine, a breakdown product of adrenaline, may be involved in psychoses. Sloane et al. (45) administered LSD to 11 healthy controls, 12 patients with predominant depression, and 7 patients with schizophrenia. In general, slight although clinically apparent changes due to LSD were difficult to verify objectively. However, spectroscopic oximetry (an estimate of capillary change) indicated increased autonomic lability in the controls and depressives but not in the schizophrenics.

The Antagonism Between LSD and Serotonin

The numerous studies demonstrating the psychotomimetic effect of LSD suggested to some investigators (22, 46) that drugs or neurohumors antagonistic to LSD would play a major role in mental activities. The initial research that stimulated this hypothesis was performed by Gaddum (21) who found that LSD inhibited or abolished the oxytocic effect of serotonin but not that of oxytocin

on the isolated rat uterus. Shore et al. (44) studied the interaction of serotonin (5-hydroxytryptamine) and LSD in the central nervous system of the mouse and found that serotonin markedly potentiated the hypnotic effect of hexobarbitone. LSD, which itself had no effect on the hypnosis produced by the barbiturate, markedly diminished the potentiating effect of serotonin. In another study Gaddum (22) tested the effects of serotonin and various possible antagonists on the rat uterus, perfused rabbit ear and guinea pig ileum. Of the ergot alkaloids investigated, LSD was the most active and specific antagonist of the action of serotonin. Ginzel et al. (23) also found that LSD was a strong antagonist of the constrictor action of serotonin on the pulmonary vessels of the cat and the hind-leg vessels of the cat and dog.

Woolley and Shaw (50) described serotonin as a hormone that has a vital role to play in living processes. They postulated that following administration of LSD mental disturbances became apparent because (a) the antimetabolic action of LSD on serotonin diminishes the content of this substance in the brain, or (b) by increasing the amount of serotonin in the brain by competing for amine oxidase, the accumulation of excessive amounts of serotonin in the brain is permitted. In terms of these hypotheses pertaining to the "model psychosis" produced by LSD, the authors further assert that endogenous psychoses such as schizophrenia may result from either too much or too little serotonin in the brain. A real test of the hypothesis that antimetabolites of serotonin cause behavioral disturbances by interfering with the action of serotonin in the brain would be to determine whether serotonin would overcome the mental

effects of drugs, i.e. various anti-metabolites of serotonin. Unfortunately, this test has not been made. Yet, even if it had been made and the hypothesis verified, there would remain the problem of identifying an antimetabolite of serotonin in patients afflicted with an endogenous psychosis.

THE EFFECT OF LSD ON PSYCHOTICS

Although LSD made its impact on psychiatric research because of its psychotomimetic properties, it is interesting to note that it was later employed as a research therapeutic agent. Some investigators curiously felt that drugs capable of engendering a morbid state in normals could have therapeutic value for psychotics. De Giacomo (12) administered 300–500 μg. to 12 mental patients and found that in 5 an initial phase of excitation was followed by catatonia-like symptoms with stupor and catalepsy, resembling that noted after the administration of bulbocapnine. In low dosage, LSD caused mental excitation, but in high dosage, hallucinatory mental confusion and catatonia. Katzenelbogen and Fang (30) administered LSD, sodium amytal, and methedrine to 20 schizophrenic patients and found that the physiological reactions to LSD and methedrine were predominantly sympathicotonic, while those to sodium amytal were predominantly vagotonic. Emotional reactions appeared more marked with LSD than with methedrine or amytal. Since the effects of LSD and methedrine lasted considerably longer than those of amytal, there was greater opportunity for emotional catharsis and verbal production. Pennes (36) administered amytal, pervitin, mescaline, and LSD to 55 schizophrenic patients and analyzed the results in terms of normali-

zation and intensification of the pre-existing clinical symptoms. Amytal was classified as predominantly a normalizer of clinical symptoms, pervitin produced an unstable state with normalization and intensification equally evident while mescaline and LSD acted as intensifiers. Condrau (11) administered 100–280 μg. of LSD to 30 mental patients and 7 normal subjects. He found that mental patients showed a much greater resistance to behavioral change following administration of LSD than the normal subjects; moreover, LSD was generally better tolerated by the mental patients than by the normal controls. Whereas a given dose would alter the behavior of a normal individual the same dose produced no observable alteration in the behavior of the psychotic. Forrer and Goldner (19) studied the physiological and psychic responses resulting from administration of LSD to schizophrenic patients. The drug produced a slight increase in blood pressure, slight increase in pulse rate, no essential change in respiration, an increase in salivation and lacrimation, dilation of the pupils, an increase in deep reflexes, and slight ataxia. Oral administration produced pupillary dilation of marked degree, whereas conjunctival instillation produced very slight dilation. The total white blood-cell count was increased during the time of action of the drug. Euphoria occurring in outbursts was prominent. "Increased accessibility and availability with increased release of libido and greater accessibility of delusional material" was also observed. Visual hallucinations of the so-called primary type were not noted in two blind patients treated with the drug but were seen in all of the six patients with normal vision. Urinary constituents, the nonprotein nitrogen level, the EEG, cephalin-

cholesterol flocculation, weight, and temperature were not affected by the administration of this drug in doses up to 6 μg. per kilogram.

Hoch et al. (25) found after administration of either LSD or mescaline that the physiological and mental symptoms of schizophrenic patients were markedly aggravated. The changes after LSD were less intense and less diffuse than those after intravenous injection of mescaline but comparable to those after oral administration of mescaline. Visual hallucinations were less frequent after LSD but other perceptual disturbances occurred with about the same frequency. Both drugs magnified the schizophrenic structures in schizophrenic patients. Liddell (31) studied the effects of methedrine and LSD on mental processes and on the blood adrenaline level using patients suffering from various mental disorders. After an initial phase of relaxation, both drugs produced an aggravation of the clinical picture. Rapid mood swings were sometimes observed after LSD but not after methedrine. After both drugs the plasma adrenaline level rose initially, then dropped below the starting level and finally rose again. The effect of LSD on the blood sugar concentration was hardly significant.

Busch and Johnson (10) believe that LSD is a drug which induces a controllable toxic state within the nervous system, that reactivates anxiety and fear with apparently just enough euphoria to permit recall of provoking experiences. It does this, it is claimed, without the sluggishness of speech and speech difficulties so frequently encountered with amytal or the more marked confusion encountered during insulin shock therapy or electric shock therapy. LSD offers a means for more readily gaining access to the chronically withdrawn patient. The authors also believe that LSD may serve as a new tool for shortening psychotherapy. Sandison and his colleagues (41) described the results of LSD therapy in 36 patients suffering from psychoneurosis and allied conditions, 20 of whom had previously received other treatment without effect. The initial dose was usually 25 μg. and at subsequent treatments the dose was gradually increased until an "adequate" reaction was obtained. Thereafter, the drug was administered at approximately weekly intervals. As a result of the LSD therapy, it is claimed, 14 patients recovered (average of 10.4 treatments), 1 was greatly improved (3 treatments), 6 were moderately improved (average of 2 treatments), and 2 were not improved (average of 5 treatments). Eleven patients still under treatment at the time of the report were improved (average of 18.6 treatments). In one case (6 treatments) it was too early to assess the results. One patient refused further treatment after having received one dose of LSD. In another paper (40) Sandison examined the possible psychological mechanism of action of LSD by analyzing the verbal material produced under the influence of LSD and he states that it bore a striking similarity to the dream and fantasy material of patients undergoing deep analysis. LSD, according to Sandison, produced an "upsurge of unconscious material into consciousness" and this material was of great personal significance to the patient. LSD apparently permits unconscious material to become manifest and psychotherapy helps them to assimilate this material. Abramson (1) has also employed LSD as an adjunct to psychotherapy to eliminate fear of homosexuality. He reports a verbatim transcript of a patient under LSD

(40 μg.) who had previously resisted analysis of a dream related to her conflict. Under the influence of LSD the patient acquired more confidence in reconstructing and re-evaluating data for a longer period than had previously been possible without LSD.

Savage (43) studied the effects of LSD in 5 normal controls and 15 depressed patients. In the latter group 3 patients recovered and 4 improved after 1 month of LSD treatment (20–100 μg., daily, orally); four patients showed no improvement and treatment was discontinued on the remaining four for various reasons. Frederking (20), although reporting the beneficial effect of LSD as an adjunct to psychotherapy, cautions against the use of the drug in anxiety states and schizophrenia. Several other reports suggest the inadvisability of giving LSD to schizophrenic patients. Elkes et al. (15) studied the effects of several drugs on catatonic stupor and found that the response to LSD was characterized by unmotivated laughter and crying, bizarre uncontrolled behavior and an apparent activation of hallucinatory and delusional material. Hoch (26) reported that LSD (as well as mescaline) disorganizes the psychic integration of the individual. The disorganization is more apparent in schizophrenics and latent schizophrenics than in normal subjects. More specific effects of LSD on schizophrenics are reported by Savage (42). He employed doses of 10–100 μg. orally or parenterally, in 6 normals and 32 hospitalized mental patients. In normal subjects an effect was produced by 10 μg. but in acute schizophrenics, 100 μg. was required to produce a much slighter effect. In acute schizophrenics the symptoms caused by LSD appeared to be an exaggeration of symptoms that already existed. Chronic schizophrenics exhibited behavior similar to that observed in acute episodes. Schizoid patients with depression and involutional depressives complained of an intensification of anxiety, depression, and somatic symptoms. Savage, like Hoch, concluded that LSD makes it impossible for the ego to integrate the evidence of its senses and to coordinate its activities.

The evidence presented assigns some unique effects to LSD. On one hand we find that LSD reactivates anxiety and fear which is considered conducive to the elicitation of unconscious material which can be assimilated by the ego. It purportedly facilitates the acquisition of confidence required for reconstruction of personal data. On the other hand, it is reported that LSD disorganizes the psychic integration of the individual. Here then we have a state in which LSD engenders anxiety and fear and disrupts the psychic integration of individuals and yet is considered by some authors as a valuable adjunct to psychotherapy. Although a review of the therapeutic value of LSD for chronic emotional disorders seems inconsistent, there is some agreement that LSD is ineffective for anxiety states and for schizophrenia.

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COMMENTS ON TAYLOR'S "DRIVE THEORY AND MANIFEST ANXIETY"

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In her recent review (13), Taylor has performed a valuable service in clarifying the purposes and the limitations of research using the Manifest Anxiety Scale. However, in restricting the MAS to an instrument for testing predictions of Hullian drive theory, she has made it all the more important that such predictions be precise deductions from the theory. The purpose of this note is to point out certain respects in which such precision seems to be lacking.

Jessor and Hammond (3) have already pointed out the lack of theoretical basis for assuming that the MAS is a measure of drive strength. This lack weakens predictions involving the MAS by making them dependent not only on the correctness of the theory but also on the validity of the Scale, which is neither theoretically derived nor independently tested.

The same line of criticism could be expanded by pointing out how many other untested secondary assumptions are involved in predictions from the MAS. Such predictions commonly take the implicit form: "If the theory is correct, and if the MAS measures drive, and if certain numbers of competing response tendencies have certain strengths relative to one another, to the threshold, and to the range of oscillation, the difference between high and low scorers will be in a specified direction." An experimental task is then chosen which E hopes will meet all these assumptions. If the difference between groups is as predicted, this is regarded as confirming both the theory and the special assumptions.

Even if all stated assumptions are met, however, objections may be raised to the line of deduction from these assumptions to the experimental predictions. These objections, which are the primary concern of the present note, would be equally applicable to experiments using any measure of drive other than the MAS.

According to theory, increased drive favors whatever response has the greatest habit strength, at the expense of all other responses (13, pp. 304–305). This leads straightforwardly to the prediction, now repeatedly confirmed (7, 8, 10, 12), that anxious Ss, who presumably have higher drive, should condition faster than nonanxious Ss. The difficulty arises when the theory is extended to more complex learning situations, with conflicting responses for a given stimulus. In the majority of such situations nonanxious Ss show superior performance (1, 5, 6, 15); only when precautions are taken to minimize interresponse competition do anxious Ss perform better than the nonanxious (5, 9, 14). How is it possible for the theory to predict this? According to Taylor (13, p. 305), higher drive can reduce the level of correct performance under two conditions: (a) if the strongest response to a given stimulus is not the correct one; or (b) if the correct response is strongest, but competing responses which are below threshold with low drive are moved above threshold by increasing drive. Let us examine these two possibilities in turn.

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RELATIVE HABIT STRENGTHS

Taylor and Spence (15) and Farber and Spence (1) compared the performance of anxious and nonanxious Ss in multiple two-choice learning situations (a verbal and a stylus maze, respectively). No learning curves are included in either article, but it seems unlikely that learning began appreciably below chance performance of 50 per cent correct. Assuming that there were only two relevant responses, this means that as soon as S's performance rose above the chance level, the correct response was strongest (averaged across choice points). There is therefore no reason to suppose that for the majority of choice points the wrong response was stronger than the right, in fact quite the contrary. From this point of view, anxious Ss should have performed better. The opposite, however, was predicted by the authors, and was confirmed.

Montague (5) compared anxious and nonanxious groups on memorization of series of nonsense syllables. On his most difficult list the nonanxious Ss were superior, supposedly because of high interresponse competition. Again, in order to say that the correct responses were not the strongest, we would have to demonstrate that for the majority of syllables some one incorrect response was stronger than the correct one. Even with high intralist similarity and low association value it seems unlikely that this would have been the case during any appreciable part of the learning process. If it was the case, because of the importance of this information for the predictions, it is strange that no such analysis was reported.

Only those studies in which care was taken to maximize a particular wrong response-tendency for certain of the stimuli (6, 9, 11) seem to meet the criterion of making a *single* wrong response stronger than the right one at a given point in the list. Here one can reasonably predict the superiority of nonanxious Ss, which was in fact found. However, on those other items in the lists where the correct response was intended to be initially stronger, nonanxious Ss were again superior except very early in learning. This is attributed to generalization. This explanation makes the implausible assumption that a generalized response-tendency is stronger than the original, reinforced one (or else an assumption about the threshold, discussed below).

Moreover, even if some wrong response is superior in habit strength to the right one early in learning, in order for the list ever to be mastered the right responses must eventually become strongest. Increased drive at that point should in all cases improve performance. This would lead to an end-spurt in the curve for anxious Ss, relative to that for the nonanxious, when learning is carried to criterion. The prediction cannot be tested directly from published data, as the experimenters who have used the MAS as a test of drive theory have not presented learning curves for those tasks which were carried to criterion and on which nonanxious Ss were superior. Malmo and Amsel (4), however, using a different measure of anxiety, found just the opposite, an end-decrement in the anxious group.

THRESHOLD EFFECTS

Drive theorists also predict superior learning by nonanxious Ss in some cases where the correct response has the greatest habit strength, but competing responses are present. It is necessary for the prediction that these competing responses be below

threshold with low drive but above threshold with high drive. It is also necessary that the ranges of oscillation of the various responses overlap, so that the momentary excitatory potential of the weaker, incorrect responses sometimes exceeds that of the stronger, correct response. According to Taylor, under these conditions increasing anxiety should decrease level of performance.

If all the above conditions are met, it follows that the range of oscillation of the correct response must be partially below threshold under low drive; otherwise it could not overlap with the subthreshold weaker responses. Hence under low drive the correct response occurs only part of the time, its momentary excitatory potential being below threshold the rest of the time. With higher drive a portion of the oscillatory range of the weaker responses moves above threshold, permitting these responses to compete with the correct one. At the same time the correct response moves farther above threshold. Whenever with high drive an oscillation carries the momentary excitatory potential of the correct response below that of a competing response, the same oscillation would have carried it below threshold with low drive. In neither drive state, therefore, would the correct response occur. Since increasing drive raises the correct (strongest) response farther above threshold than it raises the incorrect (weaker) responses, anxious Ss should do better

even under these special conditions, contrary to Taylor's prediction.

This line of reasoning makes the simple assumption, following Hull (2, pp. 12–13) and Taylor (13, p. 304), that the response which has the greatest momentary excitatory potential, if above threshold, is the one which occurs. It might be possible to devise a more complicated assumption about response competition which would predict superiority for the nonanxious group. However, there is nothing in Taylor's article to suggest that such an added assumption is considered necessary.

CONCLUSION

It follows from the above arguments that the theoretical statement contained in Taylor's article (13) will not in fact yield the predictions which have been made from it. Perhaps the present line of argument may be invalidated by details of the learning situations used or by additional postulates in the theory. In the absence of published references to such special considerations, however, criticism of the thinking behind use of the MAS as a test of drive theory appears justified. The apparent empirical fact that high anxiety is associated with poorer performance in complex situations cannot be regarded as a prediction from current drive theory, but rather in many situations as a refutation of it. What reconciliation of theory and fact is possible remains to be seen.

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RECIPE FOR A COOKBOOK

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Meehl (**2, 3, 4**) and Rosen (**4**) have directed the attention of psychologists to the fact that a predictor having substantial validity may be worse than useless in predicting a dichotomous criterion when the base rate (the percentage of the criterion population in the key category of the dichotomy) is very high or very low, and the cutting point has been set without regard to the base rate. They consider validity primarily in terms of two percentages: p_1 = valid positives (members of the key category correctly identified by the predictor), and p_2 = false positives (members of the non-key category predicted to be in the key category); show that in many cases in which $p_1 > .5$ and $p_2 < .5$, the total percentage of cases correctly categorized by the predictor is lower than the total percentage correctly categorized merely by predicting everyone to be in the more numerous category; and present formulas in p_1, p_2, and P (the base rate) which tell when this state of affairs will occur.

They imply that p_1 and p_2 can be determined without reference to the base rate, and that when the above-described state of affairs does occur, the only sensible procedure is to discard the predictor despite its substantial validity. The purpose of this note is to point out that the base rate is an essential part of every validity study, that p_1 and p_2 determined without reference to the base rate are quite meaningless, and that *every* valid continuous predictor, properly used, can give better predictions than those given by the base rate alone.

We will consider just one example from the Meehl-Rosen paper.

"In the Neurology service of a hospital a psychometric scale is used which is designed to differentiate between patients with psychogenic and organic low back pain. . . . At a given cutting point, this scale was found to classify each group with approximately 70 per cent effectiveness upon cross validation; i.e., 70 per cent of cases with no organic finding scored above an optimal cutting score, and 70 per cent of surgically verified organic cases scored below this line. Assume that 90 per cent of all patients in the Neurology service with primary complaint of low back pain are in fact 'organic'."

The authors then present Table 1 (the first part of their Table 3) for 100 patients. Evidently 7 psychogenics and 63 organics were correctly classified by the scale, or 70 in all. By classifying everyone as organic, however, 90 would have been correctly classified.

This scale has been misused; the cutting point is very far from optimal. The optimal cutting score to predict a dichotomous criterion from a continuous predictor is the point of intersection of the smoothed predictor frequency distributions for the two criterion categories, and the areas of the two frequency distributions *must* be proportional to the base rate. For the Meehl-Rosen example, the situation is shown approximately by Fig. 1, in which the area under the curve at the left is nine times the area under the curve at the right. The likelihood that a person

494

$$n_1 p_1$$

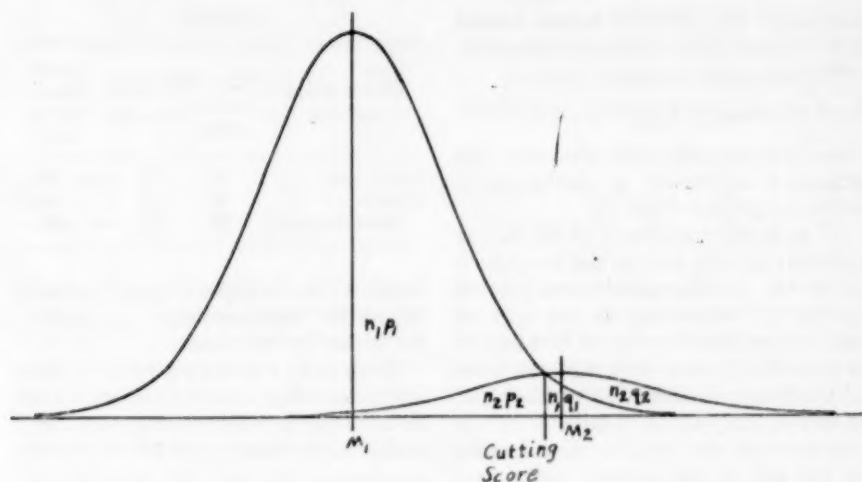$$n_2 p_2 \quad n_1 q_1 \quad n_2 q_2$$

$$M_1$$

Cutting
Score

$$M_2$$

FIG. 1

with a particular score will be found in a given criterion group is proportional to the ordinate of the frequency distribution for that criterion group at the particular score level. To the left of the point of intersection, all ordinates of the left-hand curve exceed the corresponding ordinates of the right-hand curve; hence all persons having scores below this point are more likely to lie in the larger criterion group than in the smaller. To the right of the point of intersection, all ordinates of the right-hand curve exceed the corresponding ordinates of the left-hand curve; hence all persons having scores above this point are more likely to be in the smaller criterion group than in the larger. Choice of the point of intersection as the cutting score maximizes the over-all likelihood of correct classification on the basis of the predictor score.

In the experimental validation study, the grouping interval for the predictor scores should be small enough to make the standard deviation of the grouped scores greater

than 3.5 for each criterion group. In this case an appropriate smoothing formula for any given frequency, f_0, is given by

$$\bar{f}_0 = (-2f_3 + 3f_2 + 6f_1 + 7f_0 + 6f_{-1} + 3f_{-2} - 2f_{-3})/21.$$

This is a weighted average of the given frequency and the three adjacent frequencies on each side. At the tails of the distribution some of the adjacent frequencies will be zero, and at the extreme tails, where the smoothed frequencies given by the formula become negative, they should be dropped. This formula preserves parabolic and cubic trends over each set of seven points, but smooths out irregularities of higher order. Unlike unweighted moving averages, it does not inflate the standard deviation systematically, nor affect the kurtosis to any appreciable degree. Since it does smooth out fourth-power trends, it cannot be used where a seven-point range includes two points of inflection; hence the requirement that the standard de-

viation of the grouped scores exceed 3.5. If such fine grouping cannot be achieved, a five-point formula is

$$\bar{f}_0 = (-3f_2 + 12f_1 + 17f_0 + 12f_{-1} - 3f_{-2})/35.$$

This formula will work whenever the standard deviation of the grouped scores is greater than 2.5.

If n_1 is the frequency of the larger criterion group, and n_2 the frequency of the smaller, the areas are as labeled in Fig. 1. Here $n_1 p_1$ is the area of the larger distribution to the left of the cutting point, and $n_1 q_1$ the area of the larger distribution to the right of the cutting point. Similarly $n_2 p_2$ is the area of the smaller distribution to the left of the cutting point, and $n_2 q_2$ the area of the smaller distribution to the right of the cutting point. Since both distributions are drawn on the same score-scale, the area $n_1 p_1$ includes the area $n_2 p_2$, and the area $n_2 q_2$ includes the area $n_1 q_1$. The percentage $P = 100 n_1/(n_1 + n_2)$ is the base rate for diagnosis "organic," here 90%. It is quite evident that no possible sliding of the smaller distribution along the base line (the larger distribution remaining fixed) can give a cutting point for which p_1 is as low as 70%.

From the fact that p_1 and q_2 are both given as 70% in the example, we can conclude with fair confidence that the original validity study employed criterion groups of equal size. This is good experimental design. The error probably consisted in setting the cutting score on the basis of the two experimental distributions themselves. It should have been set by using a vertical scale nine times as large for the "organic" distribution as for the "psychogenic" distribution. In general, the dichotomy given by the predictor should yield proportions fairly close to the base rate if the cutting point is optimal. In

TABLE 1

Classification by Scale	Actual Diagnosis		Total Classified by Scale
	Psychogenic	Organic	
Psychogenic	7	27	34
Organic	3	63	66
Total diagnosed	10	90	100

Table 1, the marginal distribution is 66:34 for the predictor as against 90:10 for the base rate.

With only the data given, we cannot show what the conditions would be with the correct cutting score, but under fairly reasonable additional assumptions we can do so approximately. We will assume that the joint predictor-criterion distribution is a bivariate normal distribution, and that the predictor variances are equal in the two criterion groups. There may be some objection to the assumption that the criterion distribution is normal, but some "organic" low back pain may well be complicated by secondary psychogenic factors, and some "psychogenic" low back pain by secondary organic factors: the normal assumption is at least no worse than the two-point assumption. We will also assume that in the original validity study the two groups were of equal size. Finally, we must assume the bivariate normal distribution in the validation sample. This is clearly inconsistent with the same assumption for the population; we can only hope the inconsistency will not be great enough to invalidate our conclusions.

With the assumption of criterion groups of equal size, we have the fourfold of Table 2. The figures can be taken as percentages. From this table the tetrachoric correlation, using the Chesire-Saffir-Thurstone computing diagrams (1), is .60. Assum-

<div style="text-align:center">TABLE 2</div>

Classification by Scale	Actual Diagnosis		Total Classi-fied by Scale
	Psycho-genic	Organic	
Psychogenic	35	15	50
Organic	15	35	50
Total diagnosed	50	50	100

<div style="text-align:center">TABLE 3</div>

Classification by Scale	Actual Diagnosis		Total Classi-fied by Scale
	Psycho-genic	Organic	
Psychogenic	6	2	8
Organic	4	88	92
Total diagnosed	10	90	100

ing the same tetrachoric correlation with a 90–10 split of the criterion variable, we find that 6 of the 10 psychogenics will be correctly classified. Referring again to Fig. 1, which has been so drawn that $n_2 q_2$ includes .6 of the area of the smaller distribution, it appears that $n_2 p_2$ is about twice as great as $n_1 q_1$, so we complete the fourfold as in Table 3. In this table 94% are correctly classified. With a base rate far from .5, the gain by the use of the scale is small, but it is still a gain.

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